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PUBLISHED BY THE SOCIETY
1892–1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY

OF

WASHINGTON

VOLUME VII
1892

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WASHINGTON, D. C.
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1892–1893

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OFFICERS AND COUNCIL

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON,

ELECTED JANUARY 9, 1892.

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OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

FOR 1892.

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C. HART MERRIAM, *ex officio.*

RICHARD RATHBUN.	LESTER F. WARD.

VOL. VII, PP. XVII-XXIV APRIL 8, 1893

PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON.

PROCEEDINGS.

January 9, 1892. *186th Meeting.*

TWELFTH ANNUAL MEETING.

The PRESIDENT in the chair and 23 persons present. The annual reports of the Treasurer and Recording Secretary were presented, and the officers for the year 1892 elected. (See page v.)

January 23, 1892. *187th Meeting.*

The PRESIDENT in the chair and 18 persons present.

COMMUNICATIONS.

C. W. STILES: "Notes on Parasites; *Myzomimus*, gen. nov."[1] Discussed by Dr. THEOBALD SMITH.

THEODOR HOLM: "Studies of the Morphological Identity of the Stamens." Discussed by Mr. COVILLE, Dr. STILES, and Dr. MERRIAM.

---

[1] Notes on parasites: 4, Preliminary note on *Myzomimus* gen. nov. type species *M. scutatus* (Mueller, 1869), Stiles, 1892. Journ. Comp. Medicine and Veterinary Archives, 1892, pp. 65-67, 1 fig.

On the Anatomy of *Myzomimus scutatus*. Festschrift zum siebenzigsten geburtstage Rudolf Leuckarts, 1892, pp. 126-133, taf. xvii, figs. 1-29.

THEOBALD SMITH: "Peculiar Forms of Red Corpuscles in Mammalia in Anæmic Conditions."[1]

February 6, 1892. *188th Meeting.*

The PRESIDENT, Dr. C. HART MERRIAM, delivered the annual address, entitled "The Geographic Distribution of Life in North America."[2]

The meeting was held in the law lecture-room of Columbian University, there being 132 persons present.

February 20, 1892. *189th Meeting.*

The PRESIDENT in the chair and 41 persons present.

A committee, consisting of Mr. WALCOTT, Mr. LUCAS, and Mr. RATHBUN, was appointed to revise the Constitution and By-Laws of the Society.

COMMUNICATIONS.

W. H. DALL: "Factors in the Distribution of Animal Life as Illustrated by Marine Forms." Discussed by Mr. WALCOTT, Mr. FERNOW, and Dr. DALL,

F. A. LUCAS: "On *Carcharodon mortoni*, Gibbes."[3]

J. M. HOLZINGER: "On the Identity of *Asclepias stenophylla* and *Acerates auriculata*."[4] Discussed by Professor WARD, Mr. FERNOW, Mr. COVILLE, Mr. WALCOTT, Dr. DALL, Dr. CURTICE, Professor SEAMAN, Dr. ERWIN F. SMITH, Dr. BAUER, Mr. LUCAS, Mr. BANKS, and Dr. STILES.

March 5, 1892. *190th Meeting.*

The PRESIDENT in the chair and 35 members present.

COMMUNICATIONS.

FREDERICK V. COVILLE: "Conditions Affecting the Distribution of Plants in North America." Discussed by Mr. LUCAS, Mr.

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[1] On changes in the red blood corpuscles in the pernicious anæmia of Texas cattle fever. Trans. of the Assoc. of American Physicians for 1891.

Bulletin No. 1, Bureau of Animal Industry: Investigations into the nature, causation, and prevention of Texas or Southern cattle fever (pp. 56, 68). by Theobald Smith and F. L. Kilborne, Washington.

[2] Proc. Biol. Soc. Wash., vol. vii, Apr. 13, 1892, pp. 1–64, 1 map.

[3] On *Carcharodon mortoni*. Proc. Biol. Soc. Wash., vol. vii, July, 1892, pp. 151, 152.

[4] The identity of *Asclepias stenophylla* and *Acerates auriculata*. The Botanical Gazette, vol. xvii, April, 1892, pp. 124, 125.

Walcott, Dr. Merriam, Dr. Stejneger, Professor James, Dr. Dall, Professor Riley, Mr. Fernow, and Mr. Coville.

Charles Hallock (read by Mr. Lucas): "The Physiology of a Pocoson." Discussed by Mr. Waite and Mr. William Palmer.

Vernon Bailey: "The Homes of Our Mammals."

Theodor Holm: "The Flora of Nova Zembla." Discussed by Mr. Swingle.

March 19, 1892. *191st Meeting.*

The President in the chair and 70 persons present.

COMMUNICATIONS.

Lester F. Ward: "The Biological Basis of Psychology." Discussed by Dr. Reyburn, Mr. Fernow, Professor Riley, Mr. McGee, Dr. Dall, Dr. Merriam, and Professor Ward.

C. D. Walcott: "On the Discovery of Certain Cambrian Fossils on the Coast of Massachusetts."[1]

F. H. Knowlton: "The Fossil Flora of the Bozeman Coal Field."[2] Discussed by Professor Ward, Mr. Walcott, and Mr. Knowlton.

C. W. Stiles: "Notes on Parasites—*Strongylus rubidus.*"[3]

April 2, 1892. *192d Meeting.*

The President in the chair and about 65 persons present.

COMMUNICATIONS.

C. V. Riley: "The Interdependence of Plants and Insects."[4] Discussed by Professor Ward, Dr. Gill, and Professor Riley.

C. Hart Merriam: "The Distribution of Tree Yuccas." Discussed by Mr. Gilbert, Mr. Coville, Mr. Van Deman, Mr. Hasbrouck, and Professor Riley.

H. E. Van Deman: "Variations in the Fruit of *Hicoria Pecan.*" Discussed by Professor Seaman, Professor Ward, Mr.

---

[1] Note on Lower Cambrian fossils from Cohassett, Mass. Proc. Biol. Soc. Wash., vol. vii, July 27, 1892, p. 155.

[2] The Fossil Flora of the Bozeman Coal Field. Proc. Biol. Soc. Wash., vol. vii, July 27, 1892, pp. 153, 154.

[3] Albert Hassall and C. W. Stiles: *Strongylus rubidus*, a new species of Nematode, parasitic in pigs. The Journal of Comparative Medicine and Veterinary Archives, 1892, pp. 207–209, figs. 1–3.

[4] Proc. Biol. Soc. Wash., vol. vii, May 28, 1892, pp. 81–104.

Van Deman, Mr. Simpson, Mr. Hasbrouck, Mr. Fernow, and Mr. Brunk.

April 16, 1892. *193d Meeting.*

The President in the chair and 19 persons present.

COMMUNICATIONS.

C. W. Stiles: "Notes on Parasites: *Tænia ovilla* in its Relation to Blanchard's Classification."[1] Discussed by Professor Doran, Dr. Gill, and Dr. Stiles.

Frederick V. Coville: "Flora of the High Sierra Nevada of California." Discussed by Mr. Fairchild and Mr. Mann.

Frederick V. Coville: "New Plants from California, Nevada, Utah and Arizona."[2] Discussed by Dr. Merriam, Mr. Fairchild, Mr. White, and Mr. Coville.

Erwin F. Smith: "A Review of Baillon's Botanical Dictionary." Discussed by Dr. Gill, Professor Seaman, and Dr. Smith.

J. N. Rose: "Mexican Leguminosæ, with Notes on Dr. Palmer's Collection.

April 30, 1892. *194th Meeting.*

The President in the chair and 48 persons present.

The proposed new Constitution and By-Laws, recommended by the Council for adoption, were read.

COMMUNICATIONS.

W J McGee: "The Distribution of Land, Water, and Ice on This Continent in Later Geological Periods." Discussed by Dr. Merriam, Mr. Gilbert, and Mr. McGee.

Erwin F. Smith: "The Relations of Plants to the Soil." Discussed by Mr. Fairchild.

May 14, 1892. *195th Meeting.*

The President in the chair and 23 persones present.

COMMUNICATIONS.

W. H. Seaman: "The Photogenic Organs of Fire Flies." Discussed by Mr. Mann, Dr. Gill, Dr. Merriam, and Dr. Theobald Smith.

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[1] Notes sur les Parasites: Sur le Tænia giardi. Compt. rend. d. l. Soc. d. Biologie, Paris, 1892, pp. 664, 665 (note préliminaire).

[2] Description of new plants from Southern California, Nevada, Utah, and Arizona. Proc. Biol. Soc. Wash., vol. vii, May 18, 1892, pp. 65–80.

C. HART MERRIAM: "A New Prairie Dog from Mexico."[1] Discussed by Professor WARD.

CHARLES HALLOCK (read by Mr. LUCAS): "Where Salt-water Fishes Hide: Results of Deep-water Seining." Discussed by Dr. GILL.

THEODOR HOLM: "Additions to the Flora of Washington."[2] Discussed by Professor WARD.

FREDERICK V. COVILLE: "The Use of Certain Terms in Geographic Distribution." Discussed by Dr. MERRIAM, Professor WARD, and Dr. GILL.

May 28, 1892. *196th Meeting.*

The PRESIDENT in the chair and 23 persons present.

The new Constitution and By-Laws, after a second reading, were adopted by the Society.

COMMUNICATIONS.

THEODORE GILL: "On the Super-Family Chætodontoidea."

C. HART MERRIAM: "The Plants of the Pribilof Islands."[3] Discussed by Dr. GILL, Professor RILEY, Mr. COVILLE, and Dr. MERRIAM.

C. HART MERRIAM: "Coon Cave, Missouri." Discussed by Mr. MCGEE, Dr. GILL, Professor RILEY, and Dr. MERRIAM.

June 11, 1892. *197th Meeting.*

The PRESIDENT in the chair and about 30 persons present.

COMMUNICATIONS.

C. HART MERRIAM: "The Southern Fur-Seal (*Arctocephalus*) at Guadalupe Island."[4] Discussed by Dr. GILL and Dr. MERRIAM.

FREDERICK V. COVILLE: "Uses of Plants Among the Panamint

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[1] Description of a new Prairie Dog (*Cynomys mexicanus*) from Mexico. Proc. Biol. Soc. Wash., vol. vii, July 27, 1892, pp. 157, 158.

[2] Third List of Additions to the Flora of Washington, D. C. Proc. Biol. Soc. Wash., vol. vii, June 10, 1892, pp. 105–132.

[3] Plants of the Pribilof Islands, Bering Sea. Proc. Biol. Soc. Wash., vol. vii, July 7, 1892, pp. 133–150.

[4] The Fur-Seal of Guadalupe Island, off Lower California. Fur-Seal Arbitration, Appendix to the Case of the United States, vol. i, Sept., 1892, p. 586.

Indians."[1] Discussed by Dr. ERWIN F. SMITH, Professor RILEY, and Mr. COVILLE.

J. M. HOLZINGER: "On *Amarantus crassipes.*"[2]

C. HART MERRIAM: "The Death Valley Expedition," an exhibition of lantern views. Discussed by Dr. ERWIN F. SMITH, Mr. GILBERT, Dr. GILL, Mr. VAN DEMAN, and Mr. COVILLE.

October 22, 1892. *198th Meeting.*

The PRESIDENT in the chair and 35 persons present.

COMMUNICATIONS.

FREDERICK V. COVILLE: "The Present Status of Botanical Nomenclature."

GEORGE VASEY: "Report on the Botanical Congress at Genoa."

G. B. SUDWORTH: "Some Controversial Points in Botanical Nomenclature" Discussed, together with the two preceding papers, by Dr. MERRIAM, Mr. FERNOW, Dr. GILL, and Dr. DALL.

LESTER F. WARD: "Discovery of Fossil Plants in the Potomac Formation, at the New Reservoir, Washington, D. C., and at Mount Vernon."

LESTER F. WARD: "Discovery of a Second Specimen of Saul's Oak, *Quercus prinus* × *alba.*"

November 5, 1892. *199th Meeting.*

The PRESIDENT (and Professor RILEY) in the chair and 26 persons present.

COMMUNICATIONS.

C. HART MERRIAM: "The Fauna and Flora of Roan Mountain, North Carolina."[3] Discussed by Professor COPE, Professor CHICKERING, Mr. GILBERT, Mr. FERNOW, Mr. VAN DEMAN, Dr. VASEY, Mr. SUDWORTH, Mr. HASBROUCK, Dr. GILL, and Dr. MERRIAM.

C. V. RILEY: "Pea and Bean Weevils."[4] Discussed by Mr. HOWARD, Mr. FERNOW, Dr. MERRIAM, Dr. HORN, and Professor RILEY.

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[1] The Panamint Indians of California. The American Anthropologist, vol. v, October, 1892, pp. 351–361, with plate.

[2] On *Amarantus crassipes.* The Botanical Gazette, vol. xvii, August, 1892, pp. 254, 255, with plate xvii.

[3] In part in Proc. Biol. Soc. Wash., vol. vii, Dec. 22, 1892, pp. 175–177.

[4] Insect Life, vol. v, No. 1, 1892, pp. 27–33.

VERNON BAILEY: "The Influence of the Cross Timbers on the Fauna of Texas." Discussed by Mr. VAN DEMAN, Dr. MERRIAM, Professor WARD, and Professor COPE.

November 19, 1892. *200th Meeting.*

The PRESIDENT in the chair and 24 persons present.

COMMUNICATIONS.

THEOBALD SMITH: "On Certain Minute Bodies (Parasitic?) Within the Red Blood Corpuscles."[1] Discussed by Dr. STILES, Dr. REYBURN, and Dr. ERWIN F. SMITH.

C. W. STILES: "The Topographical Relations of the Excretory Canals of Cestodes."[2] Discussed by Dr. DALL and Dr. STILES.

DAVID WHITE: "A New Walchia from New Mexico." Discussed by Professor WARD.

F. M. WEBSTER (read by the Recording Secretary): "Some Entomological Factors in the Problem of Country Fences."[3]

F. V. COVILLE: "Comparative Values of Plants in Determining Floral Zones." Discussed by Dr. MERRIAM.

December 3, 1892. *201st Meeting.*

The PRESIDENT in the chair and 26 persons present.

COMMUNICATIONS.

B. W. EVERMANN: "The Cruise of the U. S. Fish Commission Steamer *Albatross* in Alaskan Waters in 1892." Discussed by Dr. MERRIAM, Dr. GILL, Dr. DALL, Mr. TOWNSEND, and Mr. LUCAS.

GEORGE VASEY: "Some New Grasses." Discussed by Mr. DEWEY.

J. N. ROSE: "On the Rediscovery of Certain Rare Plants."

C. HART MERRIAM: "Exhibition of a Complete Series of the Large American Ground Squirrels of the Subgenus *Otospermophilus*." Discussed by Dr. GILL, Mr. COVILLE, and Dr. MERRIAM.

B. E. FERNOW: "The Mathematics of Forest Growth."

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[1] Theobald Smith and F. L. Kilborne: Investigations into the nature, causation, and prevention of Texas or Southern cattle fever. Bull. No. 1, Bureau of Animal Industry, U. S. Dept. Agriculture, 1893, p. 68.

[2] Bemerkungen über Parasiten 17. Ueber die topographische Anatomie des Gefäss systems in der Familie Tæniadæ; Centralblatt für Bakteriologie und Parasitenkunde, vol. xiii, 1893, p. —, figs. 1–12.

[3] Some entomological factors in the problem of country fences. Science, vol. xx, Dec. 16, 1892, pp. 337, 338.

December 19, 1892. *202d Meeting.*

The PRESIDENT in the chair and 28 persons present.

COMMUNICATIONS.

B. E. FERNOW: "What Should be the Scope and Object of a Biological Society?" Discussed by Professor SEAMAN, Professor WARD, Mr. TRUE, Mr. LUCAS, Mr. WAITE, Dr. ERWIN F. SMITH, Professor RILEY, Professor DORAN, Mr. FAIRCHILD, Mr. HOWARD, Dr. DALL, Dr. MERRIAM, and Mr. FERNOW.

LESTER F. WARD: "Frost Freaks of the Dittany." Discussed by several members of the Society.

December 31, 1892. *203d Meeting.*

THIRTEENTH ANNUAL MEETING.

The PRESIDENT in the chair and 18 members present.

The reports of the Corresponding Secretary, Recording Secretary, and Treasurer were presented and accepted.

The Society then proceeded to the election of officers for the year 1893.

VOL. VII, PP. 1-64 APRIL, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THE GEOGRAPHIC DISTRIBUTION OF LIFE IN NORTH AMERICA

WITH SPECIAL REFERENCE TO THE MAMMALIA.*

BY C. HART MERRIAM, M. D.

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* Annual Presidential Address, delivered at the Twelfth Anniversary Meeting of the Biological Society of Washington, February 6, 1892.

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INTRODUCTORY REMARKS.

Nine years ago the Biological Society listened to an address from its distinguished retiring President, Professor Gill, on "The Principles of Zoogeography," or the science of the geographical distribution of animals.* Professor Gill assembled the oceans of the globe, as well as the land areas, into primary divisions or

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* Proc. Biological Society of Washington, vol. II, 1884, 1–39.

'zoological realms,' of which he recognized 9 for the land and 5 for the sea. It is not my purpose to discuss the zoological regions of the whole world, but to lay before you some of the facts concerned in the distribution of terrestrial animals and plants in North America with special reference to the number and boundaries of the sub-regions and minor life areas, and to touch upon the causes that have operated in their production.

No phenomenon in the whole realm of nature forced itself earlier upon the notice of man than certain facts of geographic distribution. The daily search for food, the first and principal occupation of savage man, directed his attention to the unequal distribution of animals and plants. He not only noticed that certain kinds were found in rivers, ponds, or the sea, and others on land, and that some terrestrial kinds were never seen except in forests, while others were as exclusively restricted to open prairies, but he observed further, when his excursions were extended to more distant localities or from the valleys and plains to the summits of neighboring mountains, that unfamiliar fruits and insects and birds and mammals were met with, while those he formerly knew disappeared.

Thus primeval man, and in truth the ancestors of primeval man, learned by observation the great fact of geographic distribution, the fact that particular kinds of animals and plants are not uniformly diffused over the earth, but are restricted to more or less circumscribed areas.

It will be observed that two classes of cases are here referred to, namely, (1) cases in which in the same general region certain species are restricted to swamps or lowlands, while others are confined to dense forests or rocky hillsides—differences of *station*, and (2) cases in which, regardless of *local* peculiarities, a general change takes place in the fauna and flora in passing from one region to another, or from low valleys or plains to high mountains—*geographic* differences. The latter class only is here considered.

Every intelligent schoolboy knows that elephants, lions, giraffes and chimpanzees inhabit Africa; that orangs and flying lemurs live in Borneo; kangaroos in Australia; the apteryx in New Zealand; the Royal Bengal tiger in India; llamas, chinchillas and sloths in South America; the yak in the high table lands of Thibet, and so on. In accordance with these facts naturalists long ago began to divide the surface of the globe into zoological and botanical regions irrespective of the long recognized geographic and political divisions.* It was found that different degrees of relationship exist between the indigenous animals and plants of different countries, and that as a rule the more remote and isolated the region and the earlier in geologic time its separation took place, the more distinct were its inhabitants from those of other regions. Each of the larger islands lying near the equator and the continental masses of the southern hemisphere were found to possess not only peculiar species and genera, but even families and orders not found elsewhere; and it was discovered that insular areas of considerable magnitude that have had no land connection with other areas since very early times possess faunas and floras remarkable for the antiquity of their dominant types. In Australia, the most disconnected of all the continents, the entire mammalian fauna, though wonderfully diversified in appearance and habits, belongs to the primitive orders of monotremes and marsupials, whose best known representatives are the duck-billed platypus and the kangaroo. In the latter group Australia and neighboring islands contain no less than six families not found in any other part of the world.

Madagascar is the exclusive home of the remarkable aye-aye (*Chiromys*) and *Cryptoprocta*, the latter believed to be intermediate between the cats and civets.

Tropical America is alone in the possession of true ant-eaters (*Myrmecophagidæ*), sloths (*Bradypodidæ*), marmosets (*Hapalidæ*), armadillos (*Dasypodidæ*) and agouties (*Dasyproctidæ*).

Africa is the home of many groups not known elsewhere. Among them are the giraffe, hippopotamus, *Orycteropus*, elephant shrews (*Macroscelididæ*), *Potomogale*, and *Chrysochloridæ*.

Besides this class of cases, in which particular groups are restricted to particular countries, there is another class, in which the living representatives of single groups exist in isolated colonies in widely separated parts of the world. Illustrations of this kind are furnished by the tapirs, which inhabit tropical America and the Malay Peninsula, but do not exist in intermediate lands; by the family *Camelidæ*, represented in South America by the llamas and in parts of Eurasia by the true camels; and by a group of insectivorous mammals in which all the genera but one are restricted to Madagascar, the one exception (*Solenodon*) living in Cuba and Haiti. Examples of this sort are known as cases of *discontinuous* distribution, and indicate that the ancestors of the animals in question formerly inhabited a vast extent of country; that some sort of land connection, however indirect, existed between the colonies now so widely separated, and that the surviving descendants of these groups are probably approaching extinction.

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*Among the many distinguished naturalists who have contributed to the literature of the subject may be mentioned Humboldt, Bonpland, Buffon, De Candolle, Schouw, Engler, Agassiz, Baird, Asa Gray, Grisebach, Huxley, Gill, Allen, Wallace, and Packard.

The examples thus far cited relate to the disconnected land areas in the neighborhood of the equator or in the southern hemisphere, and their explanation is to be sought in the history of the past. In the northern hemisphere animals and plants in general have a much more extended distribution than in the southern, the majority of the larger groups being common to North America, Europe, and Asia, and the limits of their distribution are encountered in traveling in a north and south direction and are evidently the result of causes now in operation. It is to this class of cases as presented on the North American continent that your attention is invited this evening.

In passing from the tropics to the Arctic pole on the eastern side of America a number of distinct zones are crossed, the most conspicuous features of which are well known. In the plant world the palms, mangroves, mahogany, mastic, Jamaica dogwood, and cassias of the tropical coast districts are succeeded by the magnolias, pawpaws, sweet-gums, hackberries, and persimmons of the Southern States. These give place gradually to the oaks, chestnuts, and hickories of the Middle States; and the latter to the groves of aspen, maple, and beech which reach the southern edge of the great coniferous forest of the north—a forest of spruces and firs that stretches completely across the continent from Labrador to Alaska. Beyond this forest is a treeless expanse whose distant shores are bathed in the icy waters of the Arctic Ocean.

Concurrently with these changes in vegetation from the south northward occur equally marked differences in the mammals, birds, reptiles, and insects. Among mammals the tapirs, monkeys, armadillos, nasuas, peccaries, and opossums of Central America and Mexico are replaced to the northward by wood-rats, marmots, chipmunks, foxes, rabbits, short-tailed field-mice of several genera, shrews, wild-cats, lynxes, short-tailed porcupines, elk, moose, reindeer, sables, fishers, wolverines, lemmings, musk oxen, and polar bears.

The trogons, saw-bills, parrots, cotingas and other birds of tropical America give place in turn to the cardinals, blue grosbeaks, mocking birds, tufted tits, and gnatcatchers of the Southern States; the chewink, indigo bird, tanager, bluebird, and robin of the Middle and Northern States; the Canada jays, crossbills, white-throated sparrows, and hawk owls of the northern coniferous forests, and the ptarmigans, snowy owls, and snowflakes of the Arctic circle.

HISTORICAL SYNOPSIS OF FAUNAL AND FLORAL DIVISIONS PROPOSED FOR NORTH AMERICA.

The recognition of the above-mentioned facts early led to attempts to divide the surface of the land into faunal and floral regions or zones, and no less than 56 authors have proposed such divisions for North America. Of these, 31 were zoologists and 25 botanists. Of the zoologists, 10 aimed to show the distribution of animals in general, 8 of birds, 4 of terrestrial mollusks, 3 of mammals, 1 of reptiles and batrachians, and 4 of insects. Of the botanists, 22 aimed to show the distribution of plants in general and 3 of forest trees.

Of the writers who attempted to indicate the life areas of the New World prior to 1850, 68 percent were botanists, while during the next twenty years (1850–1870), 65 percent were zoologists. This striking oscillation of the biologic pendulum, first toward botany and then toward zoology, may be attributed in part at least to the influence of two great minds—Humboldt and Agassiz. Humboldt laid the corner-stone of the philosophic study of plant geography in 1805. Stimulated by his example and writings, botanists led the way and were almost the only occupants of the field until the middle of the present century, when the influence of the elder Agassiz gained the ascendency and the botanists were replaced by zoologists, who have been in the lead ever since.

The accompanying table shows the various authors referred to, the dates of the earliest publication of their divisions, the branch of biology on which their conclusions were based, and states whether or not their articles were accompanied by maps.

Latreille	1817	Insects	No map
De Candolle (Aug.)	1820	Plants	No map
Schouw	1822	Plants	Map
Martius	1824–'26	Plants	Map
Minding	1829	Mammals	No map
Pickering	1830	Plants	Map
Lesson	1831	Birds	No map
De Candolle (Alph.)	1835	Plants	No map
Meyen	1836	Plants	No map
Pompper	1841	Animals	No map
Berghaus	1838	Plants	Map
Martens and Galeotti	1842	Plants	No map
Hinds	1843	Plants	No map
Frankenheim	1843	Plants	No map
Wagner	1844	Mammals	Map
Richard and Galeotti	1844	Plants	No map
Binney (A.)	1851	Mollusks	No map
Richardson	1851	Plants	No map
Schmarda	1853	Animals	Map
Agassiz	1854	Animals	Map
Gray	1856	Plants	No map
Woodward	1856	Mollusks	Map
Sclater	1858	Birds	No map
Le Conte	1859	Insects	Map
Cooper	1859	Forests	Map
Hooker	1861	Plants	Map
Binney (W. G.)	1863	Mollusks	Map
Verrill	1863	Birds	No map
Baird	1866	Birds	No map
Murray	1866	Mammals	Map
Grisebach	1866	Plants	Map
Huxley	1868	Animals	Map
Brown	1870	Forests	Map
Allen	1871	Animals	No map
Blyth	1871	Animals	No map
Cope	1873	Repts. and batrchs.	Map
Porter	1874	Plants	Map
Scudder	1874	Insects	Map
Wallace	1876	Animals	Map
Dyer	1878	Plants	No map
Engler	1882	Plants	Map
Packard	1883	Animals	Map
Jordan	1883	Mollusks	Map
Sargent	1884	Forests	Map
Drude	1884	Plants	Map
Hartlaub	1886	Birds	Map
Reichenow	1887	Birds	Map
Heilprin	1887	Animals	Map

Hemsley	1887	Plants	Map
Brendel	1887	Plants	No map
Nelson	1887	Birds	No map
Schwarz	1888	Insects	No map
Bessey	1888	Plants	No map
Ridgway	1889	Birds	No map
Merriam	1890	Animals and plants	Map
Keeler	1891	Birds	Map

The principal bio-geographic divisions that have been recognized by a large number of writers, and as a rule have been proposed independently and under different names, resulting from the study of different groups, are described in the following synopses, each of which may be regarded as a chronologic synonymy of the region to which it refers.

Arctic Division (*Above Limit of Trees*).

An Arctic circumpolar division north of the limit of tree growth was recognized as a distinct region by European writers long before the earliest attempts were made to map the faunal and floral areas of North America.* Hence the following table is necessarily incomplete, since it shows only the extent to which this zone has been recognized by those who have actually defined faunal and floral areas in North America.

Date	*Author*	*Name given to region*	*Study based on*	*Rank*
1820	De Candolle	Hyperboreal Region	Plants	1
1822	Schouw	Realm of Mosses and Saxifrages.	Plants	1
1830	Pickering	Arctic Region	Plants	1
1831	Lesson	Arctic Region	Birds	1
1835	De Candolle	Arctic Region	Plants	1
1836	Meyen	Polar Zone	Plants	1
1838	Berghaus	Realm of Mosses and Saxifrages.	Plants	1
1843	Hinds	Greenland Region	Plants	1
1844	Wagner	Polar Province	Mammals	2

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* This region, however, is not universally recognized. Wallace and a few others refuse to accept it. Agassiz, Allen, and most botanical writers, on the other hand, regard it as one of the best defined of the primary divisions. An important recent treatise on the subject, from the standpoint of the distribution of mammals, is the following: "*Die arktische Subregion—Ein Beitrag zur geographischen Verbreitung der Thiere*," by Dr. August Brauer (Zoologische Jahrbucher, Abth. fur. Syst. III, Jan., 1888, 189–308, taf. VIII).

Date	*Author*	*Name given to region*	*Study based on*	*Rank*
1853	Schmarda	Barren Grounds	Animals	2
1854	Agassiz	Arctic Realm	Animals	1
1856	Woodward	Region of Saxifrages and Mosses.	Mollusks	1
1858	Cooper	Arctic Province	Plants	1
1866	Grisebach	Arctic-Alpine Region	Plants	1
1870	Brown	Treeless or Eskimo Province.	Forests	1
1871	Allen	Arctic Realm	Animals	1
1875	Cope	Arctic Realm	Animals	1
1878	Dyer	Arctic-Alpine Flora	Plants	2
1882	Engler	Arctic Region	Plants	2
1883	Packard	Arctic Realm	Animals	1
1883	Jordan	Arctic Province	Mollusks	2
1884	Drude	Arctic District	Plants	2
1887	Brendel	Arctic-Alpine Division	Plants	1
1887	Reichenow	Arctic Zone	Birds	1
1887	Nelson	Arctic District (Alaskan).	Birds	1
1888	Brauer	Arctic Subregion	Mammals	2
1890	Merriam	Arctic Region	Animals and plants	2

Boreal Division.

This heading is intended to cover the zone of coniferous forests extending across the continent south of the *Arctic Realm*. While its northern boundary is fixed at the limit of trees, its southern border has been variously placed by different writers. Schouw did not recognize it at all, but carried his great forest region down to latitude 36°, where the true southern district begins. Berghaus, who in other respects followed Schouw, divided this great region into two parts, the northernmost of which he named the '*Realm of Conifers*,' placing its southern limit in the east at about latitude 47°. Hinds, Agassiz, Woodward, Verrill, and Drude speak of it as the '*Canadian*' Region. Its southern limit is here extended to include the '*Canadian Fauna*' of recent zoological writers.

The extent to which this zone has been recognized will appear from the following table:

Date	*Author*	*Name given to region*	*Study based on*	*Rank*
1830	Pickering	Canadian Flora	Plants	2
1838	Berghaus	Realm of Conifers	Plants	1
1843	Hinds	Canadian Region	Plants	1
1853	Schmarda	Region of Coniferous Forests.	Animals	2

Date	*Author*	*Name given to region*	*Study based on*	*Rank*
1854	Agassiz.......	Canadian Fauna.......	Animals...........	2
1856	Woodward ...	Canadian Province.....	Mollusks...........	1
1856	Gray.........	Middle and Northern Wooded District.	Plants.............	(?)
1859	Le Conte.....	Northern Province.....	Insects............	2
1859	Cooper.......	Lacustrian Province....	Forests............	1
1863	Verrill.......	Canadian Fauna.......	Birds..............	1
1863	Binney........	Northern Region.......	Mollusks	2
1870	Brown.......	Lacustrian Province....	Forests............	1
1871	Allen........	Hudsonian and Canadian Faunas.	Animals...........	3
1882	Engler.......	Region of Conifers.....	Plants.............	2
1883	Packard......	Boreal Province........	Animals...........	1
1884	Sargent.......	Northern Forest........	Forests............	2
1884	Drude........	Canadian District......	Plants.............	2
1890	Merriam	Boreal Region.........	Animals and plants.	2

Atlantic, Central, and Pacific Divisions of Temperate North America.

It has been the custom of recent writers to divide the broad middle zone of North America (most of which lies within the United States) into three main divisions—*Atlantic* or *Eastern*, stretching from the Atlantic Ocean to the eastern border of the plains; *Central*, from the plains to the Sierra Nevada; and *Pacific*, from the Sierra to the Pacific Ocean.* These regions were proposed as early as 1854 by the elder Agassiz, who however divided the Eastern or Atlantic district into two regions of equal rank—*Alleghanian* and *Louisianian*, or faunas of the Middle and the Southern States. In this respect he has been followed by Cope. Other authors, including Le Conte, Baird, and Allen, regard the southern district as only a subdivision of the Eastern region. Agassiz named the Central region the '*Table-land or Rocky Mountain Fauna*' and the Pacific the '*Californian Fauna*.'

This arrangement of the United States into three provinces has been followed in the main by Le Conte (1859), W. G. Binney (1863), Baird (1866), Cope (1873), Grisebach (1875), Wallace

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* These divisions must not be confounded with those of Amos Binney (published in 1851) bearing the same names, for Binney's Atlantic region lay between the Atlantic and Alleghanies, his Central region between the Alleghanies and the Rocky mountains, and his Pacific region between the Rocky mountains and the Pacific. Woodward's divisions (1856) are essentially those of Amos Binney.

(1876), Allen (1878), Packard (1883), Jordan (1883), Hartlaub & Newton (1886), and Heilprin (1887).

The three divisions will be considered separately.

Atlantic or Eastern Forest Region.—Many writers have recognized an eastern forest region stretching from the plains to the Atlantic and in a general way from the boreal or coniferous forests of the north to the alluvial lands of the South Atlantic and Gulf States; but its northern and southern limits have been by no means agreed upon. Schouw defined these boundaries as the limit of trees on the north and latitude 36° on the south, and named the region Michaux's Realm or *Realm of Asters and Solidagos.* Berghaus retained Schouw's southern boundary, but took off a broad belt on the north, which he named the *Realm of Coniferous Forests.* The resulting northern limit as shown on his map (1838) agrees closely with that adopted by such recent writers as Wallace (1876), Allen (1878), Packard (1883), and Heilprin (1887), all of whom, on the other hand, carry its southern boundary south to the Gulf of Mexico, thus making it coextensive with the *Atlantic* or *Eastern Province* already referred to.

Several early writers, among whom Schouw and Berghaus were prominent, recognized this region in the east, but knew nothing of the great interior plains, and consequently spoke of it as extending all the way to the Rocky mountains.

The extent to which this Eastern Forest region has been recognized, together with the approximate north and south boundaries assigned it, will appear from the following table:

NOTE.—In the columns showing limit on the north and south the following abbreviations are used: L. T. = northern limit of trees; C. F. = northern coniferous forests; A. = Austroriparian or Louisianian region; G. = Gulf of Mexico.

Date	*Author*	*Name given to region*	*Limit on the North*	*Limit on the South*	*Based on*	*Rank*
1822	Schouw	Asters and Solidagos	L. T.	A.	Plants	1
1830	Pickering	Flora of United States	C. F.	G.	Plants	2
1838	Berghaus	Asters and Solidagos	C. F.	A.	Plants	1
1843	Hinds	Iroquoian	C. F.	G.	Plants	1
1848	Frankenheim	New England	C. F.	A.	Plants	2
1854	Agassiz	Alleghanian	C. F.	A.	Animals	2
1856	Gray	Northern States	(?)	A.	Plants	1
1859	Le Conte	Eastern	(?)	G.	Insects	1
1859	Cooper	Appalachian	C. F.	G.	Forests	1

Date	*Author*	*Name given to region*	*Limit on the*		*Based on*	*Rank*
			North	*South*		
1863	Verrill	Alleghanian	C. F.	A.	Birds	1
1863	Binney (W .G.)	Interior	C. F.	A.	Mollusks	2
1866	Baird	Eastern	C. F.	G.	Birds	1
1866	Grisebach	Forest	L. T.	G.	Plants	1
1870	Brown	Appalachian	C. F.	G.	Forests	1
1871	Allen	Eastern	C. F.	G.	Animals	2
1873	Cope	Eastern	(?)	A.	Animals	2
1874	Porter	Forest	C. F.	G.	Plants	1
1876	Wallace	Alleghanian	C. F.	G.	Animals	2
1882	Engler	Appalachian Province	C. F.	G.	Plants	3
1883	Packard	Eastern	C. F.	G.	Animals	1
1883	Jordan	Atlantic Region	C. F.	G.	Mollusks	3
1884	Sargent	Deciduous Forests	C. F.	A.	Forests	2
1884	Drude	Virginian	C. F.	G.	Plants	2
1886	Hartlaub	Alleghanian	C. F.	G.	Birds	2
1887	Heilprin	Alleghanian	C. F.	G.	Animals	2
1887	Brendel	Mixed Forest	C. F.	G.	Plants	2
1889	Ridgway	Eastern Province	(?)	G.	Birds	1

Central or Middle Division.—This division extends from the eastern border of the great plains to the Sierra Nevada and Cascade Mountains. It was first proposed by Agassiz in 1854, under the name '*Table-land Fauna or Fauna of the Rocky Mountains.*'

The extent to which it has been recognized will appear from the following table:

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1854	Agassiz	Table-land Fauna	Animals	3
1859	Le Conte	Central District	Insects	1
1863	Binney (W. G.)	Central Province	Mollusks	1
1866	Baird	Middle Province	Birds	1
1866	Grisebach	Prairie Region	Plants	1
1873	Cope	Central Region	Repts. and batrs.	2
1876	Wallace	Rocky Mountain Subregion.	Animals	2
1878	Allen	Middle Province	Animals	2
1881	Gray	Central Province	Plants	1
1883	Packard	Central Province	Animals	1
1883	Jordan	Central Region	Mollusks	3
1884	Drude	Montana District	Plants	2
1886	Hartlaub	Rocky Mountain Region	Birds	2
1887	Heilprin	Rocky Mountain Subregion.	Animals	2
1887	Brendel	Prairie Flora	Plants	1
1889	Ridgway	Rocky Mountain or Middle District.	Birds	2

Pacific or California Division.—This name has been very generally applied to the Pacific coast region of the United States. It was first recognized by the botanist De Candolle in 1820. Pickering, in 1830, named it the *Californian Flora*, but, knowing little or nothing of the Sierra Nevada and believing the Rocky Mountains to be the only mountain system of importance in North America, extended its eastern boundary to that range. In this he was followed by the botanist Hinds, in 1843; by the conchologists, Amos Binney, in 1851, and Woodward, in 1856. Agassiz, in 1854, was first to fix its eastern limit at the Sierra Nevada and Cascade mountains, where it has been permitted to rest. Its north and south boundaries have undergone considerable fluctuations.

The extent to which the Pacific or Californian region has been recognized will appear from the following table:*

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1820	De Candolle	West Coast of Temperate North America.	Plants	1
1830	Pickering	Californian Flora	Plants	2
1843	Hinds	Californian Region	Plants	1
1848	Frankenheim	California	Plants	2
1851	Binney (A.)	Pacific Region	Mollusks	1
1854	Agassiz	Californian Fauna	Animals	3
1856	Woodward	Californian Province	Mollusks	1
1859	Le Conte	Western District	Insects	1
1859	Cooper	Nevadian Province†	Forests	1
1863	Binney (W. G.)	Pacific Province	Mollusks	1
1866	Baird	Western Province	Birds	1
1866	Grisebach	Californian Region	Plants	1
1873	Cope	Pacific Region	Repts. and batrchs.	2
1874	Porter	Pacific Region	Plants	1
1876	Wallace	Californian Subregion	Animals	2
1878	Allen	Western Province	Animals	2
1883	Packard	Western Province	Animals	1
1883	Jordan	Pacific Region	Mollusks	3
1884	Drude	Californian District	Plants	2
1886	Hartlaub	Californian Region	Birds	2
1887	Heilprin	Californian Subregion	Animals	2
1887	Brendel	Californian Flora	Plants	1
1889	Ridgway	Pacific District	Birds	2

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* Engler's 'California Coast Province' is not included in this table, because it consists only of the narrow strip of land between the Coast Range and the Pacific.

† Named from the Sierra Nevada—not the State of Nevada.

Austroriparian or Louisianian Division.

(South Atlantic and Gulf States.)

Latreille, as early as 1817, called attention to the difference in the insect fauna of Carolina and Georgia from that of Pennsylvania and New York, and in his division of the earth into circumpolar zones ran the boundary line between these faunas at latitude 36°. The difference in the flora of the South Atlantic and Gulf States from that of the Northern States was recognized by the Danish botanist Schouw as early as 1822 in the '*Realm of Magnolias, or Pursh's Realm*,' which he then proposed for the region between the parallels of 30° and 36° north latitude. Thirty-four years later (in 1856) the northern boundary of the same area was run by America's greatest botanist, Dr. Asa Gray, along the parallel of 36° 30′, only half a degree from Schouw's line. The first zoologist to recognize this region was the elder Binney, who died in 1847. His posthumous work on *Terrestrial Air-Breathing Mollusks*, published in 1851, describes it under the name '*Tertiary Region of the Atlantic Coast and the Gulf of Mexico*.' The elder Agassiz recognized it in 1854 as one of his seven primary regions, naming it the *Louisianian Fauna*. Later writers, except Cope, have considered it a subdivision of the Eastern Forest region. Cope restored it to primary rank in 1873 and named it the *Austroriparian Region*.

The extent to which this region has been recognized will appear from the following table:

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1817	Latreille	Supertropical Climate	Insects	1
1822	Schouw	Realm of Magnolias	Plants	1
1836	Meyen	Subtropical Zone	Plants	1
1837	Martius	Mississippi-Floridian Realm.	Plants	1
1838	Berghaus	Realm of Magnolias	Plants	1
1851	Binney (A.)	Tertiary Region of Atlantic and Gulf coasts.	Mollusks	2
1853	Schmarda	Middle American Realm.	Animals	1
1854	Agassiz	Louisianian Fauna	Animals	3
1856	Gray	Southern States	Plants	1
1859	Le Conte	Southern Province	Insects	2
1859	Cooper	Carolinian and Missisippian.	Forests	2
1863	Binney (W.G.)	Southern Region	Mollusks	2
1866	Baird	Southern Subdivision	Birds	2
1866	Verrill	Louisianian Fauna	Birds	2
1871	Allen	Louisianian Fauna	Birds	3

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1873	Cope	Austroriparian Region	Repts. and batrchs.	2
1874	Porter	Southern District	Plants	2
1883	Jordan	Southern District	Mollusks	4
1884	Sargent	Coast Pine Region	Forests	2
1890	Merriam	Austroriparian Region	Animals and plants	2

Sonoran Division.

The term '*Sonoran Region*' has been applied by Cope and others to an important life area which enters the southwestern part of the United States from the table-land of Mexico. It was first recognized by a botanist, Richard Brinsley Hinds, R. N., surgeon to H. M. S. *Sulphur*, who published a description of it in 1843 under the name '*The Chihuahua Region.*' He defined it as extending south to the tropic, west to the Gulf of California and the Colorado River, north to the prairie region of the United States, and separated on the east from the Gulf of Mexico by a northward extension of the Central American region along the lowlands bordering the coast. Professor Baird (in 1866) stated that along the valleys of the Rio Grande and Gila the fauna of the Central Province "is greatly mixed up with the peculiar fauna of northern Mexico, which, as far as its summer birds indicate, is almost entitled to be considered as a fourth main province."

The extent to which this region has been recognized will appear from the following table:

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1843	Hinds	Chihuahuan	Plants	1
1859	Le Conte	Southwestern and South-southwestern Provinces.	Insects	2
1859	Cooper	Arizonian Region	Forests	2
1861	Cooper	Arizonian and Chihuahuan Regions.	Forests	2
1866	Baird	[No name given]	Birds	2
1870	Brown	New Mexican Region	Forests	2
1873	Cope	Sonoran	Repts. and batrchs.	2
1874	Porter	Cactus Region	Plants	1
1878	Dyer	Mexico-Californian Flora	Plants	2
1882	Engler	Aztec Province	Plants	3
1884	Sargent	Mexican Forest Region	Forests	1
1884	Drude	North Mexico and Texas District.	Plants	2
1887	Heilprin	Sonoran Transition Region.	Animals	(?)
1890	Merriam	Sonoran Province	Animals and plants	1

Peninsula of Lower California.

That the fauna and flora of the peninsula of Lower California, or any part of it, differs radically from that of the state of California immediately on the north was pointed out almost simultaneously by Baird and Le Conte in 1859. Baird stated that the fauna of its southern extremity, as determined by collections of its mammals, birds, and reptiles, "is almost identical with that of the Gila River, and to a certain extent with that of the Rio Grande," but differs wholly from that of Upper California. In accordance with these facts he afterward (in 1866) made Lower California a subdivision of the Central Province. Later in the same year (1859) Le Conte stated that a few species of insects from Cape St. Lucas, "though all new, indicate a greater resemblance to the fauna of the Lower Colorado than to that of maritime California; this province may therefore be found eventually to belong to the interior district."

Cooper (in 1861) proposed the name *Uchitan* for the Forest Flora of Lower California, and regarded it as a subdivision of his Nevadian (= Californian) Province. Grisebach also, in mapping the plant regions of the world in 1866, included the peninsula in his Californian Region, but afterward (in 1872) transferred it to the interior or prairie region.

Cope, in 1873, raised Lower California to primary rank, basing his action on a study of its reptiles and batrachians. Wallace, in 1876, placed it in the Central Province without subdivision. Packard, in 1883, followed Baird and Grisebach in regarding the southern part of the peninsula as a subdivision of the Central Province, while the northern part was assigned to the Pacific Province. Drude, in 1884, divided it transversely in two nearly equal plant areas, placing the northern half in his '*North Mexico and Texas District*,' and the southern half in his tropical '*Mexican District*.' Hartlaub and Newton, in 1886, placed the entire peninsula in their *Mexican Region*, and Heilprin, in 1887, in his *Sonoran Transition Region*.

The way in which Lower California has been regarded by different writers is shown in the following table:*

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* NOTE.—In the few cases in which the peninsula has been divided, the assignment here given relates to the southern extremity.

Date	*Author*	*How regarded*	*Study based on*	*Rank*
1837	Martius....	As part of his Mexican Extra-tropical Realm.	Plants......	0
1838	Berghaus...	As part of his Mexican Realm ('Jacquin's Realm').	Plants......	0
1843	Hinds......	As part of his Californian Region.	Plants......	0
1845	Berghaus...	As part of his Tropical Province.	Mammals....	0
1854	Agassiz.....	As part of his Californian Fauna.	Animals....	0
1856	Woodward.	As part of his Californian Province.	Mollusks....	0
1859	Baird......	As a subdivision of his Middle Province.	Birds......	2
1859	Le Conte...	As part of his Central District..	Insects......	0
1861	Cooper.....	As a subdivision of his Nevadian [= Californian] Province.	Forests......	2
1866	Grisebach..	As part of his Californian Region.	Plants......	0
1870	Brown.....	As part of his Colorado Desert District.	Forests......	0
1872	Grisebach..	As part of his Prairie Region...	Plants......	0
1873	Cope.......	As an independent region......	Reptiles and batrachians.	2
1876	Wallace....	As part of his Californian Subregion.	Animals.....	0
1882	Engler.....	As part of his Aztec Province..	Plants......	0
1883	Packard....	As part of his Central Province.	Animals.....	0
1884	Drude......	As part of his Mexican District.	Plants......	0
1886	Hartlaub...	As part of his Mexican Region.	Birds.......	0
1887	Heilprin....	As part of his Sonoran Transition Region.	Animals.....	0
1890	Merriam...	As a division of his Sonoran Province.	Animals and plants.	2

Southern Florida.

The large number of tropical forms of life inhabiting southern Florida early led to its separation from the rest of the Atlantic region by writers on the distribution of animals and plants. Lesson (in 1831) placed it along with Mexico in his South Temperate Zone. Hinds (in 1843), recognizing its Antillean affinities, placed the southern extremity of the peninsula (south of latitude 27°) in his *West India Region.*

The extent to which southern Florida has been recognized as faunally and florally distinct from the rest of the United States is shown in the following table:

Date	*Author*	*Name given to region*	*Based on*	*Rank*
1831	Lesson	[Florida division of South Temperate Zone.]	Birds	0
1843	Hinds	[Florida division of West India Region.]	Plants	0
1851	Binney (A.)	Peninsula of Florida	Mollusks	2
1858	Cooper	Floridian Region	Forests	2
1859	Le Conte	Subtropical Province	Insects	2
1866	Baird	[Florida division of Atlantic Region.]	Birds	3
1866	Verrill	[Florida division of West Indian Region.]	Birds	0
1870	Brown	Florida Subregion	Forests	2
1871	Allen	Floridian Fauna	Birds	3
1873	Cope	Floridian District	Reptiles and batrachians.	3
1874	Porter	Florida Region	Plants	1
1883	Packard	[Florida division of Antillean Region.]	Animals	0
1883	Jordan	[Florida division of Neotropical Province.]	Mollusks	0
1884	Sargent	Semi-tropical forest of Florida.	Forests	2
1887	Drude	[Florida division of Antillean Region.]	Plants	0
1887	Reichenow	[Florida division of South American Region.]	Birds	0
1887	Brendel	South Florida [Antillean]	Plants	1
1888	Schwarz	[Florida division of Antillean Region.]	Insects	0
1890	Merriam	[Florida division of Antillean Subregion.]	Animals and plants.	3

Antillean Division.

The fauna and flora of the West Indies have been variously interpreted by different writers, some placing the region in South America, others in Mexico, and others still raising it to independent rank.

In 1822 Schouw, in mapping the plant areas of the world, placed it in his '*Jacquin's Realm or Realm of Cactuses and Peppers*,' Subsequently, however (in 1833), he gave it independent primary rank, naming it '*Swartz's Realm*.' Martius, in 1837, was first to bestow the name '*Antillean Realm*' upon this region, which he regarded as a division of primary rank, comprising the West Indies and adjacent coasts of South and Central America. The same arrangement was retained in his lectures on Floral Realms in 1865.

The way in which the West Indies have been regarded by different writers is shown in the following table:

Date	*Author*	*How regarded*	*Based on*	*Rank*
1820	De Candolle	As an independent region	Plants	1
1822	Schouw	As part of his Realm of Cactuses and Peppers [Mexican].	Plants	0
1830	Pickering	As part of his American Intertropical Region.	Plants	0
1831	Lesson	As part of his Equatorial Zone.	Birds	0
1833	Schouw	As an independent realm (Swartz's Realm).	Plants	1
1835	De Candolle	As an independent region	Plants	1
1837	Martius	As an independent realm (Antillean Realm).	Plants	1
1838	Berghaus	As an independent realm (Swartz's Realm).	Plants	1
1841	Pompper	As part of his North Warm Zone.	Animals	0
1843	Hinds	As an independent realm (West India Region).	Plants	1
1845	Berghaus	As part of his Tropical Province.	Mammals	0
1846	Wagner	As part of his Tropical American Province.	Mammals	0
1854	Agassiz	As a subdivision of his Central American Region.	Animals	3
1856	Woodward	As an independent province (Antillean Province).	Mollusks	1
1858	Sclater	As part of his Neotropical Region.	Birds	0
1866	Baird	As a primary region (West Indian Region).	Birds	1
1866	Grisebach	As a primary region (West Indian Region).	Plants	1
1868	Huxley	As part of his Austro-Columbian Region.	Animals	0
1870	Brown	As an independent province (Antillean Province).	Forests	1
1875	Sclater	As an independent subregion (Antillean Subregion).	Birds	2
1876	Wallace	As an independent subregion (Antillean Subregion).	Animals	2
1882	Engler	As an independent province	Plants	3
1883	Packard	As an independent region (Antillean Region).	Animals	1
1883	Jordan	As part of his Neotropical Province.	Mollusks	0
1884	Drude	As an independent region (Antillean District).	Plants	2

Date	*Author*	*How regarded*	*Based on*	*Rank*
1886	Hartlaub.....	As an independent region (Antillean Region).	Birds.......	2
1887	Heilprin.....	As a subdivision of his Neotropical Region.	Animals....	2
1887	Reichenow...	As part of his South American Region.	Birds.......	0
1890	Merriam.....	As a division of his Tropical Province.	Animals and plants.	2

Northwest Coast Division.

In 1843 Hinds, in mapping the plant regions of the world, proposed a '*Northwest American Region*' for the area west of the Rocky Mountains, north of the Columbia River, and south of latitude 68° north. Agassiz, in his paper on the Zoological regions of the earth (1854), gave the name '*Northwest Coast Fauna*' to essentially the same area (shown on his map as extending along the Pacific from northern California to the base of the Unalaskan peninsula).

In 1859 Le Conte, who based his studies on Coleoptera, spoke of this region as the '*Hyperborean Province*' of the Pacific district; and the same year Cooper, writing of forest regions, described it as the '*Caurine Province.*' W. G. Binney, in 1873, mentioned it as the '*Oregonian Division*' of the Pacific Province; Engler, in 1882, as the '*Kaloschen Zone*'; Drude, in 1884, as the '*Columbian District*'; Nelson, in 1887, as the '*Sitkan District*'; Brendel, in 1887, as the '*North Pacific Province.*'

Prairie Division.

A few botanists, influenced by the widely different aspects of nature resulting from the presence or absence of forests, have recognized a 'Prairie Region' as one of the great floral divisions of North America. It was first proposed by Pickering, in 1830. Pickering named it the '*Louisianian Flora,*' and gave its boundaries as the Mississippi on the east and the Rocky Mountains on the west. Hinds described it, in 1843, as "a peculiar tract enclosed by the vast forests of North America." He named it the 'Prairie Region,' and said it extended "from within a hundred miles of the west bank of the Mississippi to the Rocky Mountains, stretching north to 54° north latitude, and again only bounded on the south by the wooded country of the Texas and the Mexican Sea."

Cooper, in his paper on the distribution of forests (in 1859), named it the *Campestrian Province.* It was recognized by Brown in 1870, by Porter in 1874, and by Engler in 1882.

RECAPITULATION.

It is seen that a number of zoologists and botanists, basing their studies on widely different groups, and as a rule ignorant of the writings of their predecessors, have agreed in the main in the recognition of at least seven (7) life areas in extratropical North America, namely: (1) an *Arctic area* north of the limit of tree growth; (2) a *Boreal transcontinental coniferous forest region;* (3) an *Atlantic or Eastern wooded region* stretching westward from the Atlantic to the Great Plains; (4) a *Central or Middle region*, reaching from the Plains to the Sierra Nevada and Cascade Mountains; (5) a *Pacific or Californian division*, covering the area between the east base of the Sierra and the Pacific ocean; (6) a Louisianian or *Austroriparian division*, comprising the South Atlantic and Gulf States south of latitude 36°; (7) a *Sonoran division*, occupying the high table-land of Mexico and stretching northward over the dry interior far enough to include the southern parts of California, Nevada, Arizona, New Mexico, and Texas.

With or without reference to the above principal divisions, it has been recently the custom of zoologists, particularly ornithologists, to subdivide the eastern United States and Canada into several minor areas or 'faunas,' as follows: (*a*) Floridian; (*b*) Louisianian; (*c*) Carolinian; (*d*) Alleghanian; (*e*) Canadian; (*f*) Hudsonian; and (*g*) Arctic. Of these the Canadian and Hudsonian form a part of the '*Boreal*' region above mentioned, and the Floridian and Louisianian together make up the '*Austroriparian*' division, leaving only the Carolinian and Alleghanian for the so-called 'Eastern Province' to rest on. The true relations of these zones will be explained later.

LIFE REGIONS AND ZONES OF NORTH AMERICA.

In a communication I had the honor to lay before this Society two years ago (December 4, 1889) * I stated that the Hudsonian and Canadian zones of the East belong to the *Boreal* region and extend completely across the continent, and that the desert areas of the West belong to the Southern or *Sonoran* region. The pine plateau (*Pinus ponderosa*) of Arizona and other parts of the West was "shown to consist of a mixture of Boreal and Sonoran types. * * * In other words, it is *neutral* territory" (North American Fauna, No. 3, September, 1890, p. 20). I remarked further that the Carolinian fauna "is suffused with southern forms, and the Alleghanian seems to be *neutral* ground" (Ibid. p. 18), thus implying that the 'neutral' or pine-plateau zone of Arizona is the western equivalent of the 'Alleghanian Fauna' of the East.

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* Since published in my report on the "*Results of a Biological Survey of the San Francisco Mountain Region in Arizona*," N. Am. Fauna, No. 3, September 11, 1890.

In a subsequent publication (North American Fauna, No. 5, August, 1891) I went a step further, defining the treeless parts of the 'Neutral or Transition Zone,' and characterizing an 'Upper Sonoran Zone' as distinguished from the Lower or True Sonoran; but nothing was said as to the relations of these zones with those long recognized in the East.

The time has now arrived, however, when it is possible to correlate the Sonoran Zones of the West with corresponding zones in the East, as was done two years ago in the case of the Boreal Zones, and as was intimated in the case of the Neutral or Transition Zone. It can now be asserted with some confidence not only that the Transition Zone of the West is the equivalent of the Alleghanian of the East, but also that the Upper Sonoran is the equivalent of the Carolinian, and the Lower Sonoran of the Austroriparian, and that each can be traced completely across the continent. Thus, all the major and minor zones that have been established in the East are found to be uninterruptedly continuous with corresponding zones in the West, though their courses are often tortuous, following the lines of equal temperature during the season of reproduction, which lines conform in a general way to the contours of altitude, rising with increased base-level and falling with increased latitude.

The BOREAL REGION extends obliquely across the entire continent from New England and Newfoundland to Alaska and British Columbia, and from about latitude 45° north to the Polar Sea, conforming in general direction to the trend of the northern shores of the continent. It recedes to about latitude 54° on the plains of the Saskatchewan, and gives off three long arms or chains of islands, which reach far south along the three great mountain systems of the United States—an eastern arm in the

Alleghanies, a central arm in the Rocky Mountains, and a western arm in the Cascades and Sierra Nevada. The latter at its northern base occupies the entire breadth of the Pacific Coast region from the eastern slope of the mountains to the sea, but in passing southward bifurcates, the main fork following the lofty Cascade and Sierra ranges to about latitude 36°; the other following the coast, gradually losing its distinctive characters and becoming invaded with Sonoran forms until it disappears a little north of San Francisco.

The following genera of mammals belong exclusively to the Boreal Region, none of them ranging south beyond the Transition Zone:

Cervus
Rangifer
Alce
Mazama
Ovibos
Arctomys
Aplodontia
Evotomys
Phenacomys
Myodes
Cuniculus
Zapus
Erethizon
Lagomys
Thalarctos
Latax
Gulo
Mustela
Neurotrichus (?)
Condylura

In addition to the above, the following genera are clearly of Boreal origin, although reaching and in some cases penetrating parts of the Sonoran Region:

Ovis
Bison *
Tamias
Castor
Arvicola
Fiber
Vulpes
Ursus
Lutreola
Putorius
Sorex

Besides the genera here enumerated, the following subgenera belong to the Boreal Region: *Tamiasciurus* (containing the red or spruce squirrels), *Mynomes* and *Chilotus* (field-mice or voles, of which *Mynomes* reaches south a little beyond the Transition Zone), *Teonoma* (the bushy-tailed wood-rats), and *Neosorex* and *Atophyrax* (subgenera of shrews).

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* The faunal position of the genus *Bison* is not so certain as in the case of the other genera here mentioned, though both the American and the European species seem to be of Boreal origin.

The Boreal Region is made up of two principal divisions, both circumpolar: (1) An *Arctic division*, above the limit of tree growth; and (2) A *Boreal Coniferous Forest division.*

Arctic Mammals.

(Found above the limit of trees and all circumpolar.)

A. *Exclusively Arctic.*

Eskimo	*Homo*
Polar bear	*Thalarctos maritimus*
Barren ground bear	*Ursus richardsoni*
Musk ox	*Ovibos moschatus*
Barren ground caribou	*Rangifer grœnlandicus*
Arctic fox	*Vulpes lagopus*
Arctic hare	*Lepus glacialis*
Lemming	*Myodes obensis*
Lemming	*Cuniculus torquatus*
Arctic red-backed mouse	*Evotomys rutilus*
Parry's spermophile	*Spermophilus empetra*

B. *Common to Arctic and Hudsonian.*

Wolverine	*Gulo luscus*
Gray wolf	*Canis griseus*
Ermine	*Putorius erminea*

The *Boreal Coniferous Forest division* may be subdivided into at least two transcontinental zones: (*a*) Hudsonian, and (*b*) Canadian; and a third or 'Timberline Zone' may be differentiated from the Hudsonian proper. In speaking of the divisions of the Boreal Region on high mountains it is customary to add the word *alpine* to the name of the division; thus, *Arctic-alpine*, *Hudsonian-alpine*, and so on.

Mammals of the Boreal Zone.

(The letter *a* indicates that the species is known only from mountains, or is an alpine form.)

- Cervus canadensis
- Rangifer caribou
- Alce americanus
- Mazama montana
- Ovis canadensis
  - dalli
- Sciuropterus volans sabrinus
- Sciurus fremonti
    - mogollonensis (*a*)
  - hudsonicus
    - californicus (*a*)
    - vancouverensis
  - richardsoni
  - douglassi

- Tamias cinereicollis (*a*)
  - obscurus (*a*)
  - senex (*a*)
  - speciosus (*a*)
  - townsendi
  - umbrinus (*a*)
  - quadrivittatus (*a*)
    - amœnus (*a*)
    - luteiventris (*a*)
    - borealis
    - neglectus
- Spermophilus lateralis
  - castanurus (*a*)
  - chrysodeirus (*a*)
  - cinerascens
  - armatus (*a*)
  - beldingi (*a*)
  - empetra
    - kodiacensis
  - columbianus
- Arctomys caligatus (*a*)
  - dacota (*a*)
  - flaviventer (*a*)
- Aplodontia major (*a*)
  - rufa
- Sitomys americanus arcticus
  - austerus
- Neotoma cinerea drummondi
- Phenacomys borealis
  - celatus
  - intermedius
  - latimanus
  - longicaudus
  - orophilus (*a*)
  - ungava
- Evotomys californicus
  - occidentalis
  - idahoensis
  - carolinensis (*a*)
  - dawsoni
  - galei (*a*)
  - gapperi
    - brevicaudus
- Arvicola alticolus (*a*)
- Arvicola drummondi
  - nanus (*a*)
  - oregonus
  - mordax
  - longicaudus
  - townsendi
  - macropus
  - xanthognathus
- Myodes obensis
- Cuniculus torquatus
- Zapus hudsonius
- Erethizon dorsatus
  - epixanthus
- Lagomys princeps (*a*)
  - schisticeps (*a*)
- Lepus americanus
  - bairdii (*a*)
  - washingtoni
- Lynx canadensis
- Ursus americanus
  - horribilis
- Putorius culbertsoni
  - longicauda
- Mustela americana
  - caurina
  - pennanti
- Sorex belli
  - dobsoni (*a*)
  - forsteri
  - idahoensis
  - monticolus (*a*)
  - pacificus
  - richardsoni
  - sphagnicolus
  - suckleyi
  - trowbridgei
  - vagrans
    - similis (*a*)
  - albibarbis
  - palustris
  - hydrodromus
- Condylura cristata
- Vesperugo noctivagans
- Atalapha cinerea

The SONORAN REGION as a whole stretches across the continent from Atlantic to Pacific, covering nearly the whole country south of latitude 43° and reaching northward on the Great Plains and Great Basin to about latitude 48°. It is invaded from the north by three principal intrusions of Boreal forms along the three great mountain systems already mentioned; while to the southward it occupies the great interior basin of Mexico and extends into the tropics along the highlands of the interior. It covers also the peninsula of Lower California, the southern part of which seems entitled to rank as an independent subdivision.

The following genera belong exclusively to the Sonoran Region (as distinguished from the Boreal), none of them ranging north beyond the Transition Zone. Those preceded by the letter *T* are intrusions from the Tropical Region.

T Didelphis
T Tatusia
T Dicotyles
Reithrodontomys *
Onychomys
Oryzomys
Sigmodon
Geomys
Dipodomys
Perodipus †
Microdipodops
Perognathus
Heteromys
Urocyon
Bassariscus
T Nasua
Conepatus
Spilogale
Notiosorex
Scalops
Corynorhinus
Euderma
Antrozous
Nycticejus
T Molossus
T Nyctinomus
T Otopterus

In addition to the above, the following genera seem to be of Sonoran or austral origin, although reaching and in some cases penetrating a considerable distance into the Boreal region:

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* The generic name *Reithrodontomys* was proposed by Giglioli in 1873 (Richerche intorno alla Distribuzione Geografica Generale, Roma, 1873, p. 160), and antedates *Ochetodon* of Coues.

† The generic name *Perodipus* was proposed in 1867 by Fitzinger for the five-toed kangaroo rats (Sitzungsber. math. nat. Classe, K. Akad. Wiss. Wien, LVI, 1867, p. 126), thus antedating by twenty-three years the name *Dipodops* proposed by the writer for the same type in 1890 (North Am. Fauna, No. 3, September, 1890, p. 72). Both generic names were based on *Dipodomys agilis* of Gambel, from Los Angeles, California.

Cariacus
Antilocapra
Cynomys
Sitomys[*]
Neotoma
Thomomys
T Procyon
Taxidea

Mephitis
T Felis
Lynx
Scapanus
Blarina
Atalapha
Vesperugo
Vespertilio

The genera *Sitomys*, *Mephitis*, *Lynx*, *Atalapha*, *Vesperugo*, and *Vespertilio* range well north in the Boreal Zone, where each is represented by a single species. In the Sonoran Zone, on the other hand, these same genera reach their maximum development and are represented by numerous species.

Besides the genera above enumerated, a number of subgenera belong to the Sonoran Region. Among these are *Neosciurus* and *Parasciurus* (subgenera of *Sciurus*), *Xerospermophilus*,[†] *Ammospermophilus*[‡] and *Ictidomys* (subgenera of *Spermophilus*), *Pitymys*, *Pedomys* and *Neofiber* (subgenera of *Arvicola*), and *Chætodipus* (a subgenus of *Perognathus*, which is almost entitled to rank as a full genus).

The Sonoran Region may be divided by temperature into two principal transcontinental zones, (*a*) *Upper Sonoran*, and (*b*) *Lower Sonoran;*[§] and each of these in turn may be subdivided into *arid* and *humid* divisions.

The gray fox, *Urocyon*, ranges over both Upper and Lower Sonoran from Atlantic to Pacific; and pocket gophers of the genus *Geomys* inhabit both these divisions on the Great Plains and in the Mississippi Valley, and range east to the Atlantic in the Austroriparian Zone.

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[*] The generic name *Hesperomys* being untenable, Allen has recently substituted for it the name *Vesperimus*, proposed by Coues as a subgenus in 1874 (Bull. Am. Mus. Nat. Hist., III, No. 2, June, 1891, pp. 291–297). *Vesperimus* is antedated by *Sitomys* of Fitzinger, proposed in 1867, and based on Gapper's *Cricetus myoides* from Lake Simcoe, Ontario, Canada (Sitzungsber. math. nat. Classe, K. Akad. Wiss. Wien, LVI, 1867, p. 97). Gapper's *Cricetus myoides* is the common white-footed mouse of southern Ontario and northern New York, which therefore becomes the type of the genus.

[†] *Xerospermophilus*, subgen. nov., proposed for *Spermophilus mohavensis* (type) and the allied species of the *S. spilosoma* group.

[‡] *Ammospermophilus*, subgen. nov., proposed for *Spermophilus leucurus* (type) and allied species.

[§] The great Lower Sonoran Zone may be split lengthwise (in an east and west direction) into two belts which have not yet been thoroughly differentiated.

Both divisions of the Lower Sonoran are inhabited by the transcontinental genera *Reithrodontomys*, *Sigmodon*, *Corynorhinus*, *Nyctinomus*, *Otopterus*, *Neotoma*, and *Spilogale*, though in the west the two last mentioned range through the Upper Sonoran also.

The humid Lower Sonoran or *Austroriparian* is a division of much importance. It begins on the Atlantic seaboard at the mouth of Chesapeake Bay and stretches thence southwesterly, embracing the alluvial lands of the South Atlantic and Gulf States below what geologists know as the 'fall line,' rising in the Mississippi bottom as far as the junction of the Ohio with the Mississippi, and following the former in a narrow strip to the point where it receives the Wabash. On the west side of the Mississippi it crosses Arkansas, reaches southern Missouri and southeastern Kansas, and spreads out over Indian and Oklohoma Territories and Texas, where it loses its moisture and merges insensibly into the arid Sonoran. *Oryzomys* and *Nycticejus* are distinctive Austroriparian genera. Six other genera (*Neotoma*, *Reithrodontomys*, *Geomys*, *Spilogale*, *Nyctinomus*, and *Corynorhinus*), which in the region east of the Mississippi seem to be restricted to this division, have a more extended range in the west. The cotton rat (*Sigmodon*), another characteristic Austroriparian genus. has a very limited range in the arid Sonoran.

The arid Lower Sonoran extends westerly from the humid Sonoran to the Pacific, covering southern New Mexico and Arizona south of the plateau rim (sending a tongue up the Rio Grande to a point above Albuquerque), the west side of which it follows northerly to the extreme northwestern corner of Arizona and the southwestern corner of Utah (where it is restricted to the valley of the lower Santa Clara, or St. George Valley), and thence westerly across Nevada, reaching northerly to Pahranagat, Oasis, and Owens Valleys, and thence curving southwesterly, following the eastern base of the Sierra Nevada, Tehachapi, and Tejon Mountains. and covers the whole of the Mohave and Colorado Deserts and all the rest of southern California except the mountains. It sends an arm southward over most of the peninsula of Lower California, and another northward covering the San Joaquin and Sacramento Valleys. The distinctive mammals of the arid Lower Sonoran are kangaroo rats of the genus *Dipodomys*, pocket mice of the subgenus *Chætodipus*, and spermophiles of the subgenera *Xerospermophilus* and *Ammospermophilus*.

The peninsula of Lower California is a subdivision of the arid Lower Sonoran Zone. Not a single genus of land mammal or bird is restricted to it and but two peculiar species of mammals have been described. The peculiar birds are more numerous, but with few exceptions are only subspecifically separable from those of neighboring parts of the United States and Mexico. They may be classed in two categories: (1) Mountain forms derived from the North (of Boreal or Transition origin); and (2) lowland forms derived from the contiguous plains (of Sonoran, or in one instance subtropical, origin). As would be expected from the character of the country, the great majority are subspecies of well-known Sonoran forms, with the addition of a small number of peculiar species belonging to Sonoran genera. But a single subtropical bird is known, namely, *Dendroica bryanti castaneiceps*, and it is restricted to the mangrove lagoons.

The presence of this subtropical bird in the narrow coast lagoons is in complete accord with the vegetation of the coast strip, which, as Mr. T. S. Brandegee tells us, is subtropical.* This indicates the presence of a narrow coast belt similar to that of southern Florida, but of less extent. It is possible that *Basilinna xantusi* is subtropical rather than Sonoran, but the details of distribution of the genus are not well known.

Among reptiles, about 25 peculiar species of snakes and lizards are believed to be restricted to the peninsula, but no peculiar genus is known. Three of the genera are tropical, and nine are arid Lower Sonoran.

In addition to the peculiar species and subspecies of the peninsula, many characteristic arid Lower Sonoran forms of mammals, birds, reptiles, insects, and plants abound. Among the latter may be mentioned the highly distinctive Sonoran desert brush, *Larrea mexicana* and *Krameria parvifolia*.

Cope includes the whole peninsula in his *Lower Californian Region*, but other writers restrict the peculiar fauna and flora to the end of the peninsula south of the north foot of the mountains between La Paz and Todos Santos. Bryant states: "There is no more sharply defined faunal and floral area, that occurs to me now, excepting that of islands, than is embraced in the region above defined,"* but he omits to name the forms by which it is characterized. It is evident, however, that the peculiar fauna of the peninsula of Lower California entitles it to rank as a minor subdivision of the Lower Sonoran Zone. It is in effect an insular fauna of recent origin, bearing the same relation to that of the mainland as do several of the adjacent islands.

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* Brandegee, Proc. Calif. Acad. Sci., 2d ser., III, 1891, 110.

The humid division of the Upper Sonoran comprises the area in the eastern United States commonly known as the Carolinian Fauna. The opossum (*Didelphis*) here finds its northern limit, as do the so-called pine mouse (subgenus *Pitymys*) and the Georgian bat (*Vesperugo georgianus*). Before reaching the 100th meridian this area gradually loses its moisture and spreads out over the Great Plains as the arid or true Upper Sonoran, reaching an altitude of about 4,000 feet along the east foot of the Rocky Mountains in the latitude of Colorado, and sending a tongue northward along the Missouri obliquely through North Dakota and into eastern Montana. Another subdivision of the arid Upper Sonoran occupies the greater part of the Great Basin between the Rocky Mountains and the High Sierra, reaching northerly from the upper border of the Lower Sonoran to and including the plains of the Columbia and Snake Rivers. Another part of noteworthy extent is a narrow belt encircling the interior basin of California—the valley of the Sacramento and San Joaquin rivers—and a branch of the same along the coast between Monterey and the Santa Barbara plain. The following genera of mammals find their northern limit in the arid Upper Sonoran Zone: *Perodipus*, *Microdipodops*, *Perognathus*, *Onychomys*, *Spilogale*, *Urocyon*, *Bassariscus*, and *Antrozous*.

Interposed between the Boreal and Sonoran Regions throughout their numerous windings and interdigitations, is the Neutral or Transition Zone. The humid division of this zone, known as the Alleghanian Fauna,† covers the greater part of New

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* Walter E. Bryant in Zoe, II, No. 3, Oct., 1891, 186. See also his important 'Catalogue of the Birds of Lower California,' Proc. Calif. Acad. Sci., 2d ser., II, 1889, 237–320.

† Prof. Louis Agassiz, in his highly important work on Lake Superior, clearly recognized the transition nature of this zone, for he says: "The State of Massachusetts, with its long arm stretched into the ocean eastward, or rather the region extending westward under the same parallel through the State of New York, forms a natural limit between the vegeta-

England (except Maine and the mountains of Vermont and New Hampshire) and extends westerly over the greater part of New York, southern Ontario, and Pennsylvania, and sends an arm south along the Alleghanies all the way across the Virginias, Carolinas, and eastern Tennessee, to northern Georgia and Alabama. In the Great Lake region this zone continues westerly across southern Michigan and Wisconsin, and then curves northward over the prairie region of Minnesota, covering the greater parts of North Dakota, Manitoba, and the plains of the Saskatchewan; thence bending abruptly south, it crosses eastern Montana and Wyoming, including parts of western South Dakota and Nebraska, and forms a belt along the eastern base of the Rocky Mountains in Colorado and northern New Mexico, here as elsewhere occupying the interval between the Upper Sonoran and Boreal Zones.

In Wyoming the Transition Zone passes broadly over the well-known low divide of the Rocky Mountains, which affords the route of the Union Pacific railway, and is directly continuous with the same zone in parts of Colorado, Utah, and Idaho, skirting the Boreal boundaries of the Great Basin all the way around the plains of the Columbia, sending an arm northward over the dry interior of British Columbia, descending along the eastern base of the Cascade Range and the High Sierra to the southern extremity of the latter, and occupying the summits of the Coast Ranges in California and of many of the desert ranges of the Great Basin.

The Transition Zone, as its name indicates, is a zone of overlapping of Boreal and Sonoran types. Many Boreal genera and species here reach the extreme southern limits of their distribution, and many Sonoran genera and species their northern limits. But a single mammalian genus (*Synaptomys*) is restricted to the Transition Zone, and future research may show it to inhabit the Boreal Region also.

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tion of the warm temperate zone and that of the cold temperate zone. * * * Not only is this also the northern limit of the culture of fruit trees, but this zone is equally remarkable for the great variety of elegant shrubs which occur particularly on its northern borders, where we find so great a variety of species belonging to the genera, Celastrus, Cratægus, Ribes, Cornus, Hamamelis, Vaccinium, Kalmia, Rhodora, Azalea, Rhododendron, Andromeda, Clethra, Viburnum, Cephalanthus, Prinos, Dirca, Celtis, &c." (Lake Superior, 1850, 182–183.)

The following Boreal genera of mammals disappear in the Transition Zone:

Tamias *
Fiber †
Evotomys
Zapus
Erethizon
Arctomys
Vulpes *
Cervus
Ovis *
Ursus *
Neurotrichus
Condylura

The following Sonoran genera of mammals disappear in the Transition Zone:

Antilocapra
Cynomys
Spilogale ‡
Geomys
Thomomys §
Perognathus
Bassariscus ‡
Urocyon ‡
Scalops

As already stated, the only mammalian genus apparently restricted to the Transition Zone is *Synaptomys*—a lemming mouse. A number of species, however, seem to be nearly or quite confined to this zone. Among these are the following:

Sciurus aberti
fossor ||
carolinensis leucotis
Tamias merriami
minimus
pictus
striatus
Spermophilus elegans
richardsoni
obsoletus
Spermophilus spilosoma pratensis
grammurus
townsendi ||
Cynomys leucurus
Sitomys nebrascensis
boylii
michiganensis
Arvicola mogollonensis
austerus minor
curtatus

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* Except one species, which inhabits a limited part of the Sonoran Region.

† *Fiber* ranges south beyond the normal limit of the Transition Zone, but it does so along the banks of cool streams that give it a much lower temperature than that of the surrounding atmosphere. It is probable that both *Fiber* and *Castor* should be classed with aquatic species, the limits of their distribution depending on the temperature of the water. The same is true in a less degree of the paludal subgenera *Neosorex* and *Atophyrax* (of *Sorex*) and of the semi-amphibious members of the subgenus *Mynomes* (of *Arvicola*).

‡ These genera barely enter the Transition Zone at all except in a very small area in the far West.

§ Except on high mountains in the Sonoran Region.

|| Range down into Upper Sonoran also.

Arvicola pallidus
Synaptomys cooperi
Lepus americanus virginianus
campestris
idahoensis *
sylvaticus nuttalli *
Perognathus fasciatus
olivaceous
Putorius nigripes *
Vulpes velox
Scapanus americanus
Vespertilio melanorhinus

Local elevations of the land in the Sonoran Region are capped with isolated patches of Transition or Boreal species, according to the temperature to which their summits attain; and if the elevation is sufficient to secure a Boreal fauna and flora the latter is always separated from the Sonoran of the surrounding plane by a belt or girdle of Transition Zone forms.

The TROPICAL REGION reaches the United States at two remote points—Florida and Texas. In the former it exists as a narrow subtropical belt encircling the southern half of the Peninsula from Cape Malabar on the east to Tampa Bay on the west. In Texas it crosses the Lower Rio Grande from Mexico and extends north to the neighborhood of the Nueces River. In western Mexico the Tropical Region reaches Mazatlan.

Fourteen families of Tropical mammals inhabit North America north of Panama, namely:

Didelphidæ
Bradypodidæ
Myrmecophagidæ
Dasypodidæ
Dicotylidæ
Tapiridæ
Octodontidæ
Dasyproctidæ
Procyonidæ
Solenodontidæ
Emballonuridæ
Phyllostomatidæ
Hapalidæ
Cebidæ

Of the above fourteen families, six reach the United States, namely, *Didelphidæ*, *Dasypodidæ*, *Dicotylidæ*, *Procyonidæ*, *Emballonuridæ*, and *Phyllostomatidæ*, and two of the latter (*Didelphidæ* and *Procyonidæ*) penetrate the entire breadth of the Sonoran Region, the *Procyonidæ* even entering the lower edge of the Boreal. Descending from families to genera, it is found that no less than 62 tropical genera of non-pelagic mammals inhabit North America north of Panama, of which number 9 enter the United States from Mexico, namely, *Didelphis*, *Tatusia*, *Dicotyles*, *Nasua*, *Procyon*, *Felis*, *Molossus*, *Nyctinomus*, and *Otopterus*. Of these, *Didelphis*, *Felis*, and *Procyon* now reach considerably further north than the others, as just pointed out in speaking of the families to which they respectively belong. In explanation of this extended range it is found that these genera inhabited North America in pre-glacial times and as a consequence have become acclimatized to a wider range of climatic conditions. The semi-Tropical belt of Florida is not known to possess any tropical mammals except bats and a large indigenous mouse (*Sitomys macropus*)*, but it has not been explored by experienced mammal collectors. Still, its recent origin and complete isolation from other tropical areas would indicate the absence of terrestrial species derived from the south. At the same time it is known to be rich in tropical plants, land shells, insects, and birds, as is shown in another part of the present paper (see pp. 51–53). It contains 9 genera of tropical birds, namely, *Zenaida*, *Geotrygon*, *Starnœnas*, *Rostrhamus*, *Polyborus*, *Crotophaga*, *Euetheia*, *Callichelidon*, and *Cœreba*.

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* Range down into Upper Sonoran also.

The following 62 genera of mammals belong to the North American Tropical Region. The nine preceded by the letter *S* enter the southern United States, which they penetrate varying distances. *Nyctinomus* and *Otopterus* inhabit the Lower Sonoran Zone in common with the Tropical; *Didelphis* pushes completely through the humid division of the Sonoran Region; and *Felis* and *Procyon* enter the lower edge of the Boreal.

NORTH AMERICAN TROPICAL GENERA.

Chironectes
S Didelphis
Bradypus
Cholœpus
Myrmecophaga
Tamandua
Cycloturas
S Tatusia
S Dicotyles
Elasmognathus
Capromys
Plagiodontia
Echinomys
Synetheres
Dasyprocta
Cœlogenys
S Felis
S Procyon
Bassaricyon
S Nasua
Cercoleptes
Galictis
Solenodon
Natalus
Rhynchonycteris
Saccopteryx
Diclidurus
Noctilio
S Molossus
S Nyctinomus
Chilonycteris
Mormops
Lonchorhina
S Otopterus
Vampyrus
Micronycteris
Trachyops
Phyllostoma
Mimon
Hemiderma
Glossophaga
Phyllonycteris
Monophylla
Leptonycteris
Glossonycteris
Chœronycteris
Artibeus
Vampyrops

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* Described by the writer as *Hesperomys macropus* in N. Am. Fauna, No. 4, Oct., 1890, p. 53.

Stenoderma
Chiroderma
Pygoderma
Sturnira
Brachyphylla
Centurio
Desmodus
Diphylla
Midas
Mycetes
Chrysothrix
Nyctipithecus
Ateles
Cebus

Recapitulating, it is found that of the one hundred and thirty four genera of non-pelagic mammals inhabiting North America north of Panama, fifty-three are exclusively Tropical, twenty exclusively Sonoran, and twenty exclusively Boreal. In addition to these genera, which do not outstep the limits of the regions to which they severally belong, a number of others are clearly referable to the same regions, though ranging varying distances beyond their proper boundaries. Including these genera, the number belonging to each region is as follows: Tropical, sixty-two; Sonoran, thirty-four; Boreal, thirty-one—thus leaving but seven genera out of a total of one hundred and thirty-four that are not distinctly referable to one of the three regions. One of these (*Synaptomys*) is not known to occur outside the limits of the Transition Zone, leaving but six genera that have not been assigned. These genera are *Sciuropterus*, *Sciurus*, *Spermophilus*, *Lepus*, *Canis*, and *Lutra*, each of which ranges over large parts of both Boreal and Sonoran Regions. All except *Spermophilus* inhabit the Tropical Region also, and all are of great antiquity, as will be shown presently (p. 37). The genera *Spermophilus* and *Lepus* might be referred to the Sonoran Region because the great majority of their species are confined to it; and for the same reason *Sciurus* might be considered Tropical and Sonoran.

Omitting Mexico and Central America, and regarding the nine intrusive Tropical genera already mentioned as Sonoran (in contradistinction to Boreal), it is found that eighty-one genera of non-pelagic mammals inhabit the United States and Canada, of which forty-three may be looked upon as of Sonoran origin and thirty-one as of Boreal origin. The seven genera remaining are those mentioned in the last paragraph.

Table showing the Geographic Distribution of North American Genera of non-pelagic Mammals occurring north of Mexico.

Boreal Genera.

Cervus
Rangifer
Alce
Ovis *
Mazama
Bison (?)
Ovibos
Tamias *
Arctomys
Aplodontia
Castor *
Arvicola *
Fiber *
Evotomys
Phenacomys
Myodes
Cuniculus
Zapus
Erethizon
Lagomys
Vulpes*
Ursus *
Thalarctos
Latax
Gulo
Mustela
Lutreola *
Putorius *
Sorex*
Neurotrichus (?)
Condylura

Sonoran Genera.

Cariacus †
Antilocapra
Cynomys
Reithrodontomys
Onychomys
Sitomys†
Oryzomys
Sigmodon
Neotoma †
Geomys
Thomomys
Dipodomys
Perodipus
Microdipodops
Perognathus
Heteromys
Lynx †
Urocyon
Bassariscus
Taxidea
Conepatus
Mephitis †
Spilogale
Notiosorex
Blarina†
Scapanus
Scalops
Corynorhinus
Euderma
Antrozous
Nycticejus
Vesperugo †
Atalapha †
Vespertilio †

Tropical Genera.

Didelphis
Tatusia
Dicotyles
Felis †
Procyon †
Nasua
Molossus
Nyctinomus
Otopterus

Transition Zone Genera.

Synaptomys

Genera Inhabiting both Boreal and Sonoran Zones.

Sciuropterus
Sciurus
Spermophilus
Canis
Lutra
Lepus

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* Having one species in Sonoran Zone or reaching Sonoran.

† Having one species in Boreal Zone or reaching southern edge of Boreal.

DISTINCTNESS OF THE TROPICAL REGION FROM THE SONORAN.

It has been shown that the fauna and flora of Tropical America reach the United States, though in a somewhat dilute condition, along the lower Rio Grande in Texas, and in southern Florida, and that in the vast majority of cases their genera and species differ widely from those of other parts of America. Except for the presence, chiefly in the southern United States, of a comparatively few forms derived from the Tropical region, the fauna and flora of North America are as distinctive and independent of the existence of this area as if separated from it by the broad ocean. Among the eighty-one genera of non-pelagic *Mammalia* inhabiting North America north of Mexico the number of these intrusive genera is only nine,* as has been shown, and three of these are bats. These genera are: *Didelphis*, *Tatusia*, *Dicotyles*, *Felis*, *Procyon*, *Nasua*, *Molossus*, *Nyctinomus*, and *Otopterus*. *Tatusia* and *Nasua* barely reach our southern boundary; *Dicotyles* extends only part way through Texas; *Molossus* a short distance into southern California; *Nyctinomus* and *Otopterus* do not pass beyond the Lower Sonoran Zone, and *Didelphis* is restricted to the humid division of the Sonoran. Out of the nine intrusive genera, therefore, but two (*Felis* and *Procyon*) reach the southern edge of the Boreal.

On the other hand, a few groups, such as the wolves, otters, squirrels, and rabbits (genera *Canis*, *Lutra*, *Sciurus*, *Sciuropterus*, *Spermophilus*, and *Lepus*) occur over large parts of both North and South America, presenting a seeming obstacle to the acceptance of the view that the faunas in question are so wholly dissimilar. But investigation shows that these animals are almost world-wide in distribution, implying great antiquity of origin, and remains of most of them have been found as low down at least as the Miocene strata in both America and Eurasia. Hence it is clear that these types became diffused over North and South America at a very distant period, and their peculiar habits of life, though wholly dissimilar, enabled them to survive the great mutations these land areas have undergone since Miocene times.

The paucity of species of tropical derivation in North America is the more remarkable in view of the absence of barriers of any kind, save climatic conditions alone, to impede the free ingress of species from the south. No mountain range or arm of the sea or other tangible obstacle marks the northern boundary of the semi-tropical fauna of northeastern Mexico where it ends abruptly near the Nueces River in Texas, or the semi-tropical belt of Florida where it ends near Tampa Bay on the west and Cape Malabar on the east.

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*Among birds the number of intrusive forms is greater, as would be expected from their superior powers of locomotion and dispersion.

If the Tropical fauna and flora stopped at the narrow Isthmus of Panama, or even in southern Nicaragua, where the last union of the North and South American continents probably took place, the case would be very different; but instead of doing this it pushes northward 1,500-2,000 miles and ends abruptly where the most painstaking search fails to reveal any barrier to further extension except an uncongenial decrease in temperature and humidity (see also remarks under change of climate following Pleistocene times p. 44.)

No more striking illustration could be desired of the potency of climate compared with the inefficiency of physical barriers than is presented by the almost total dissimilarity of the North American Tropical and Sonoran Regions, though in direct contact, contrasted with the great similarity of the Boreal Regions of North America and Eurasia—now separated by broad oceans, though formerly united, doubtless, in the region of Bering Sea. Of the thirty-one Boreal genera of North American mammals all but eight, or three-fourths, occur also in Eurasia, and but a single family is restricted to cold-temperate America. This family (the *Aplodontidæ*) is the sole representative of a group approaching extinction, and the accident of its survival (in a single genus and two closely related species) in a very limited area along our west coast can hardly be construed as of much faunal significance. Contrasted with this one family (which ought not to be counted) and eight genera of Boreal North American mammals not occurring in Eurasia, Tropical North America (Central America and part of Mexico, exclusive of the West Indies) has no less than eight families and fifty-three genera not belonging to the immediately adjoining Sonoran Region of the southern United States and the plateau of Mexico.

THE SONORAN NOT A TRANSITION REGION.

Before leaving this part of the subject reference should be made to the view recently advanced by some naturalists, notably by

Angelo Heilprin, that the Sonoran Region is itself a 'Transition Region' between the Boreal and Tropical Faunas and Floras. The incorrectness of this hypothesis is easily demonstrated, for it rests upon the assumption that the Sonoran Region is a mixture of Boreal and Tropical forms. The contrary has just been shown to be the case, the hiatus between the Sonoran and Boreal on the one hand and the Sonoran and Tropical on the other being not only immense, but vastly greater than that between Boreal America and Eurasia.

DIFFERENTIATION OF LIFE FROM THE NORTH SOUTHWARD.

Animals and plants inhabiting the Arctic regions are usually specifically identical throughout Arctic America, Greenland, and the polar parts of Eurasia and outlying islands, while as they diverge from the pole southward they tend to split up into many species; in other words, Boreal species are more stable and persistent than those inhabiting warmer countries. The explanation of this fact is obvious. The identity of climate and environment throughout the Arctic Zone tends to preserve identity of specific characters, giving rise to a homogeneous fauna and flora, while the diversity of physical conditions and climatic influences prevailing in an increasing degree at greater distances from the pole exerts a powerful influence upon the various forms of life, producing first local geographic races or subspecies, then species, and finally groups of species constituting well-marked subgenera and even genera, giving rise to greatly diversified faunas and floras. Thus among mammals the polar or ice bear (*Thalarctos maritimus*) has no very near relative, and is replaced in the tundras by the brown and barren-ground bears (*Ursus arctos* and *richardsoni*), which run into several more or less distinct forms, as the snow bear (*U. isabellinus*), Syrian bear (*U. syriacus*), and hairy-eared bear (*U. piscator*). Besides these are the grizzly (*U. horribilis*, of which two forms may be recognized) and the black bears of America and Eurasia (*U. americanus*, *torquatus*, and *japonicus*); and still further southward the group becomes differentiated into several well-marked genera.

In like manner the Arctic fox is replaced to the southward, first, by the red foxes of America and Eurasia, of which several subspecies are known; second, by a number of quite distinct species, and third, by additional types, at least one of which in our own country is entitled to generic rank (*Urocyon*).

The ermine and polar hare are the sole Arctic representatives of groups which in the temperate parts of Europe and America comprise many distinct species, and in the case of the former, several well marked subgenera.

The Arctic lemmings (genera *Myodes* and *Cuniculus*) are numerously represented in the north temperate parts of the world by the genera *Ellobius*, *Synaptomys*, *Phenacomys*, *Erotomys*, *Fiber*, and *Arvicola*.

It is not to be inferred from the above remarks that the polar representatives of these various groups are to be looked upon as the parent stocks from which the other members sprang. Usually the reverse is the case, for groups of Boreal origin that now attain their maximum development in north-temperate regions have their numbers reduced in the Arctic circle to a single representative. But, regardless of centers of origin, it is here intended to emphasize the fact that types inhabiting the Arctic Zone are few in number and uniform in character throughout their distribution, while to the southward the same types become more and more diversified and new types appear as the distance from the Pole increases,* so that it may be formulated as a general proposition that in continental areas *the further from the Poles the larger the number of families, genera, and species.*†

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*The elder Agassiz long since pointed out that "the vegetation of the two continents becomes more and more homogeneous the more we advance northward" (Lake Superior, 1850, 153). Stated conversely, this is in complete accord with the "Law of differentiation from the north southward" formulated by Allen as "a constant and accelerated divergence in the characters of the animals and plants of successive regions of the continent." (Bull. Mus. Comp. Zool. II, 1871, 379.) In a later contribution the same author speaks of the "high rate of differentiation favored by tropical conditions of climate," and adds that Arctic and cold-temperate climates are characterized by only slightly or moderately diversified faunas; that a moderate increase of temperature results in the addition of many new types; and that "a high increase in temperature, giving tropical conditions of climate," is accompanied by "a rapid multiplication of new forms and a maximum of differentiation."

†This is a general proposition intended to apply to terrestrial forms of life *collectively*, and does not conflict with the law that the maximum number of species in each particular group is found in the zone or area which is the center of its distribution.

ORIGIN OF TYPES AND FAUNAS—GEOLOGIC EVIDENCE.

In speaking of the Boreal and Sonoran origin of species and groups in the present paper, the term '*origin*' is used exclusively in a sense intended to indicate *present centers of distribution*—not real or ancient centers of origin—for it must be borne in mind that the history of the inhabitants of the earth is not only a history of the successive appearance and disappearance of types now extinct, but a history of great movements—of vast migrations to and fro over the surface of the globe—and little is known of the real points of origin of our Boreal and Tropical faunas and floras. The geologic evidence demonstrates that in the past large land areas have been many times joined together and many times rent asunder. The establishment of land continuity between areas previously disconnected has made it possible for new forms of animals and plants to obtain a footing and spread over regions previously uninhabited by them—often, doubtless, at the expense of the indigenous fauna and flora. Even great continents, as North and South America, have been more than once united and separated; and the last union of these continents it so recent we can distinctly trace at the present day the course and distribution of the intrusive forms.

On the other hand, in comparatively recent times, multitudes of species and genera, and even families and higher groups, have suddenly disappeared from large areas where they were formerly abundant, and some of them from the face of the earth, so that the fauna of the recent past compared with that of today presents some strange contrasts. North America in Pleistocene times was inhabited by associations of mammals not now living on this continent but found in as far distant parts of the earth as Asia and South America; for horses, camels, and elephants then lived here with llamas, tapirs, and capybaras. With them were others now altogether extinct, as huge tigers, wolves, cave bears, the great Mastodon, the Megatherium, Megalonyx, Mylodon, and other gigantic sloths.

GLACIAL EPOCH.

The cause of this sudden extermination of dominant types is believed to have been the Glacial epoch, which is known to have driven species of animals and plants from the poles to the tropics, and which explains several of the otherwise inexplicable problems presented in the study of the past and present distribution of life.

The snows at the beginning of the Glacial epoch fell upon a continent of great forests—forests that gave shelter to multitudes of mammals and birds and other forms of life, a large proportion of which no longer inhabit America, and many of which do not exist in any part of the globe.

During the period of maximum development the great glacier is believed to have been not less than 8,000 feet in thickness in northern New England, and its southern border crossed New Jersey and Pennsylvania, and thence, curving irregularly southwesterly to southern Illinois and then northwesterly, finally reached the Pacific Ocean in British Columbia. The disastrous effect upon animals and plants of this tremendous body of ice must have reached far south of its actual borders.

The Glacial epoch is believed to have been made up of at least two principal and a number of minor advances and retreats, separated by long intervals and accompanied doubtless by corresponding fluctuations in the northern boundaries of the faunal and floral areas immediately to the south ; for it is reasonable to suppose that throughout the period covered by the movements of the ice mantle, and probably in later preglacial times as well, the forms now known as Boreal and Arctic (or their immediate ancestors) inhabited areas characterized by temperatures not very different from those they now require, and that the northern limit of each species kept at a certain uniform distance from the ice line. "Plants," says Dr. Gray, "are the thermometers of the ages, by which climatic extremes and climates in general are best measured."

Important evidence of the correctness of this hypothesis is afforded by the well known presence of colonies or assemblages of arctic species on isolated mountain summits in southern latitudes, where the altitude carries them into the low temperature of their homes in the far North. It is obvious that such colonies could not have reached their present positions during existing climatic conditions. But during the return movement of animal and plant life following the retreat of cold at the close of the Glacial epoch, many Boreal species were stranded on mountains, where, by climbing upward as the temperature increased, they were enabled to survive, finding a final resting place with a climate sufficiently cool for their needs, and here they have existed to the present day.*

Throughout the growth of the great ice mass and its extension from the north southward it is clear that the animals and plants that could not keep pace with its advance must have perished, while the steady pushing toward the tropics of those that were able to escape to the rapidly narrowing land in that direction must have resulted in an overcrowding of the space available for their needs and a corresponding increase in the severity of the struggle for existence. The sustaining capacity of a region is limited; hence such a thing as overcrowding, in the sense of greatly increasing the number of organisms a region can support, is an impossibility, for beyond a certain limit all excess of life must perish—overcrowding inevitably leading to death. The mortality in any one year may not have been great, but during the untold ages covered by the movements of the continental ice the aggregate destruction of life must have been stupendous.

Immediately upon the close of the Glacial epoch life began to reclaim the regions from which it had been so long shut out. This overflow released the tension under which the animals and plants had been struggling for ages and rendered the contest for existence less severe. Overproduction had at last found an outlet, and life became possible to a constantly increasing number of individuals. Normal reproduction was sufficiently rapid to supply occupants for the regions made habitable by the slow recession of the ice, and the advance of both plants and animals kept pace, doubtless, with its progressive increase. But the species that survived to return were only in part those driven out. Many had been overtaken by the cold or had perished in the journey southward; others were driven into inhospitable regions where the environment was not suited to their needs; others still succumbed in the struggle resulting from overcrowding, and some that outlived the first great period of glaciation perished during the second. Gilbert tells us that a detailed study of the ancient lake beds of the

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*In a former communication attention was called to the circumstance that the presence or absence of such arctic-alpine colonies on high volcanic mountains may be of use to the geologist as affording evidence of the age of the volcanic activity resulting in the upheaval of the mountain, the absence of Arctic or Boreal forms indicating postglacial origin. (N. Am. Fauna, No. 3, September, 1890, p. 21.)

Great Basin "shows two lacustral epochs corresponding to two glacial epochs, and correlates the mammalian fauna with the later half of the later Glacial epoch. Presumptively this date falls very late in the Pleistocene period." (Lake Bonneville, by G. K. Gilbert, 1890, 397.) The mammalian fauna referred to comprises an elephant, an otter, two horses, three llamas, a deer of the genus *Cervus*, an ox, a gigantic sloth, together with three species now living, namely, the coyote, beaver, and pocket gopher (*Thomomys*). No new types came in to take the place of those exterminated; hence we in the United States now live in a region deprived of many of the groups to which it gave birth, and we are forced to visit remote parts of the earth to see animals and plants that once attained their maximum development in North America, while others that formerly flourished here are entirely extinct.

Not only are the pre-Pleistocene animals and plants now represented imperfectly and in greatly reduced numbers, but the areas at present inhabited by their descendants, except in the case of the Boreal forms, are insignificant in comparison with their former extent. It should be remembered that the refrigeration of the Glacial epoch has only in part disappeared. In early Pliocene times characteristic representatives of subtropical faunas and floras existed northward over much of the United States and Canada, and in still earlier times reached the Arctic Circle.* During the advance of cold in the Glacial epoch these forms were either exterminated or driven southward into the narrow tropical parts of Mexico and Central America. The retreat of cold at the termination of this period was not complete, and our continent has never regained its former warmth. Hence the expelled species were not permitted to advance more than a short distance into the region formerly occupied by them, and the tropical species have been held back and at the present day are not found except along the extreme southern confines of our territory. For example, peccaries in early Pleistocene times ranged northward over a large part of western America, while at present they are restricted to parts of Texas and Louisiana below the Red River of the South; and the capybaras, tapirs, and other tropical forms whose fossil remains have been found in many parts of the United States have not been able to return. The same is true of plants, for the palms, tree-ferns, and numerous other tropical types that formerly ranged over much of our country are now either altogether extinct or exist only in the tropics.

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* Among trees fossil remains of magnolia, sassafras, and liquidamber have been found in Greenland.

The llama and many plants now inhabiting the Andes may be looked upon as representing a class of cases in which Boreal forms were driven so far south that they actually reached the great mountain system of South America and spread southward over its elevated plateaus and declivities to the extreme end of the continent in Patagonia and Terra del Fuego. This fact has been long recognized by botanists.

The paleontologic history of the earth shows that many groups now unknown came into existence from preceding groups, gradually attained a maximum development, and as gradually passed away; but there are few records of breaks in the geologic series, or of disturbances of any kind from the earliest appearance of life to the present time, that have resulted in the destruction of so many types as the cold of the Glacial epoch.

CAUSES CONTROLLING DISTRIBUTION.

It is now pretty generally conceded that temperature and humidity are the chief factors governing the distribution of life, and that temperature is more potent than humidity. Illustrations of this law have been already given in contrasting the humid and arid elements of the several zones with the zone elements as limited by temperature, and it has been found in the case of mammals and birds that the effects of temperature, estimated numerically, are more than three times greater than the effects of humidity upon genera, and many times greater upon the higher groups.

Authors differ as to the exact period during which temperature exerts the greatest influence, but there can be little doubt that for both animals and plants it is *the season of reproductive activity*, and hence varies inversely with latitude and altitude. In high arctic latitudes this period is very brief, while in the humid tropics it seems to extend over nearly if not quite the whole year.*

Whether the temperature in question is the mean of a certain period or the sum of the daily temperatures for that period, or the sum in excess of a certain minimum, expressed in degrees of the thermometric scale or in calories, and how to determine the precise beginning and ending of this period for each locality. are questions respecting which difference of opinion prevails; and authors are not agreed as to whether the temperature should be taken in the sun or in the shade, or at a certain distance below the surface of the earth. At the same time it has been demonstrated by Linsser and others that a definite quantity of heat is required to complete the process of reproduction in a number of plants experimented upon—and nature's laws are not framed for isolated cases. This law is taken advantage of by expert gardeners and horticulturists who are able to so regulate the temperature of their green-houses that they can produce a perfect flower or a ripe fruit on a specified day.

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* This was pointed out by the author in North Am. Fauna No. 3, September, 1890, pp. 26–27.

A few species, particularly among plants, are so sensitive to cold that they are limited in northward range by the line of killing frost, but in the vast majority of cases the winter temperature is of no consequence. As I have already shown, "The season of reproduction for the plant, as for the animal, is the warm part of the year. After the period of reproduction the plant withers; after it flowers and fruits and matures its seed, it dies down or becomes physiologically inactive. And what the plant accomplishes in one way the animal accomplishes in another. To escape the cold of winter and its consequences, the sensitive mammal hibernates; the bird migrates to a more southern latitude; the reptile and batrachian dig holes in the mud or sand and remain in a torpid condition; the insect sleeps in its cocoon or buries itself under leaves or decomposing vegetation; and none but the hardier forms of life are left to be affected by winter temperatures." (N. Am. Fauna, No. 3, September, 1890, 26–27.)

After temperature and humidity, several subordinate though important factors remain to be considered. Among these may be mentioned the duration and actinic effects of sunlight (governed in part by percentage of cloudiness or fog and by the mechanical purity of the atmosphere). The character of the soil also determines the presence or absence of many species.*

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* The controlling causes of distribution will not be discussed further here because they are the subject of another communication upon which the writer is engaged.

EFFECTS OF HUMIDITY CONTRASTED WITH EFFECTS OF TEMPERATURE.

With few exceptions, the Boreal zones, owing to their low temperatures, precipitate sufficient moisture to support arboreal vegetation and do not possess arid areas. The Transition and Sonoran zones on the other hand naturally fall into two important subdivisions, *arid* and *humid*, as indicated in defining their courses. As a rule the former consist of treeless plains, deserts, and barren mountains, while the latter are bountifully clothed with forests. Most of the humbler forms of vegetation are different in the two subdivisions, and differences exist also among the mammals, birds, and reptiles; but the great majority of these dissimilarities are not of the same kind as those that distinguish one zone from another. Most of them are specific—not generic—and the number of distinctive groups of high order is very much less. This may be made clear by selecting the distinctive elements of the arid Sonoran (which has the largest number of peculiar forms) in comparison with those of the humid Sonoran (or Austroriparian) and contrasting them numerically with the distinctive elements of the Sonoran as a whole compared with those of the Boreal as a whole.* Among non-pelagic mammals, the arid Sonoran has one family (*Antilocapridæ*) and only ten genera † not known to inhabit the humid Sonoran or Austroriparian; and the latter has but one family (*Didelphidæ*) and four genera (*Didelphis*, *Oryzomys*, *Scalops*, and *Nycticejus*) not found in the arid Sonoran (and the family and one of the genera are intrusions from the Tropical region), while 13 families and 27 genera are common to both arid and humid subdivisions.‡

Among birds, the arid Sonoran has no family and only 24 genera not inhabiting the humid Sonoran, and the latter has no family and but 7 genera not found in the arid, while 12 families and 31 genera are common to the two divisions.

Contrasting the Sonoran as a whole with the Boreal as a whole, it appears that there are no less than 8 families and 41 genera of mammals and 10 families and about 100 genera of birds distinctive of the Sonoran, and 6 families and 30 genera of mammals and 3 families and about 40 genera of birds distinctive of the Boreal zone. In other words, taking mammals and birds together, the arid Sonoran has one peculiar family and only 34 distinctive genera, and the humid Sonoran one family and 11 genera (of which the family [*Didelphidæ*] and several of the genera are clearly intrusions from the Tropical region), while the Sonoran as contrasted with the Boreal has 18 distinctive families and 141 distinctive genera, and the Boreal has 9 distinctive families and 70 distinctive genera.

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* The intrusive Tropical genera are here treated as Sonoran.

† These genera are: *Antilocapra*, *Cynomys*, *Onychomys*, *Thomomys*, *Dipodomys*, *Perodipus*, *Microdipodops*, *Perognathus*, *Bassariscus*, and *Antrozous*.

‡ The newly discovered genus of *Chiroptera*, *Euderma*, is here omitted because only a single specimen is known and it cannot yet be satisfactorily assigned to its proper faunal position.

Only 8 families and 8 genera of mammals are common to the Boreal and Sonoran Regions. The common families are: *Cervidæ*, *Muridæ*, *Sciuridæ*, *Leporidæ*, *Mustelidæ*, *Canidæ*, *Felidæ*, and *Soricidæ*. The common genera are: *Sitomys*, *Sciurus*, *Sciuropterus*, *Spermophilus*, *Lepus*, *Lutra*, *Canis*, and *Lynx*. Several others inhabit limited parts of both regions, but are not common to these regions as a whole.

With the possible exception of the gray wolf, not a single species of mammal ranges throughout the Sonoran and Boreal Zones, though a number are common to the Upper Sonoran and Lower Boreal (Canadian); and in the case of the wolf it is almost certain that comparison of specimens will show the animal of the southern United States and Mexico to be perfectly distinct from that of Arctic America. The ermine is another species of phenomenal though less extensive range, if it is really true that the weasel inhabiting the shores and islands of the Polar Sea is specifically identical with that found in the more elevated parts of the Southern States—an assumption I cannot for a moment entertain.

In the case of land birds, 18 genera are common to the Boreal and Sonoran Regions. The number of common families is relatively large as would be expected from the wide dispersal of most families of birds. For instance, the *Turdidæ* or thrushes inhabit North and South America, Eurasia, Africa, India, and Australia; the *Paridæ* or titmice inhabit North and South America, Eurasia, Africa, India, Australia, and New Zealand; the *Cinclidæ* or dippers inhabit North and South America, Eurasia, India, and the Austro-Malayan region; the *Troglodytidæ* or wrens inhabit North and South America, Eurasia, India, Africa, and the Austro-Malayan region; the *Corvidæ* or crows, magpies and jays, are found in every part of the world, and so on.

Table Showing Number of Distinctive Families and Genera of Mammals and Birds of the Arid Sonoran Compared with the Humid Sonoran, and of the Sonoran as a Whole Compared with the Boreal as a Whole.

	Mammals		Birds		Total	
	Fam.	Gen.	Fam.	Gen.	Fam.	Gen.
Arid Sonoran distinguished from Humid Sonoran by...........	1	10	0	24	1	34
Humid Sonoran distinguished from Arid Sonoran by........	1	4	0	7	1	11
Common to both Arid and Humid Sonoran	13	27	12	31	25	58
Sonoran as a whole distinguished from Boreal by..............	8	41*	10	100	18	141
Boreal as a whole distinguished from Sonoran by.............	6	30†	3	40	9	70
Common to Boreal and Sonoran.	8	8		18		26

Descending to species, the contrast is even more marked.

The above table shows, so far as the genera of mammals and birds are concerned, that the difference between the humid 'Atlantic' or 'Eastern Province' on the one hand and the arid Great Plains and Great Basin on the other is less than one-fourth as great as the difference between the Sonoran and Boreal Regions.

These facts, it seems to me, should suffice to establish beyond dispute the subordinate part played by humidity in comparision to temperature, and should dispel any lingering doubts that may still haunt the minds of conservative naturalists respecting the necessity of abandoning the long accepted division of the United States into Atlantic, Central, and Pacific provinces.

Remarks respecting some of Wallace's Fallacies.

Wallace, in his great work on Geographic Distribution, and in subsequent writings on the same subject, greatly underrates the importance of temperature as a factor in determining the distribution of life. He lays great stress upon the dissimilarity of the faunas and floras of parts of Africa, South America, and Australia lying in the same latitude and calls particular attention to the circumstance that although the climate may be identical over these widely separated areas, the species and higher groups are totally distinct, because the regions have been disconnected since early geologic times—as if these facts were not self-evident. On the other hand, in single continental areas where there is no break or barrier of any kind between widely different faunal zones, he tries to invent some unnatural reason for the differences observed and is reluctant to admit that even in these cases climate or climatic conditions can constitute the barriers to dispersion that undoubtedly exist. He says of climate: "Probably its action is indirect, and is determined by its influence on vegetation, and by bringing diverse groups into competition."

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* *Sitomys* and *Lynx* are omitted because they range over most of the forested part of the Boreal Region.

† *Putorius* is omitted because it ranges over much of the Sonoran Regoin.

In another place he states: "Hot countries usually differ widely from cold ones in all their organic forms; but the difference is by no means constant, nor does it bear any proportion to difference of temperature. Between frigid Canada and subtropical Florida there are less marked differences in the animal productions than between Florida and Cuba or Yucatan, so much more alike in climate and so much nearer together." He states further: "The eastern United States possess very peculiar and interesting plants and animals, the vegetation becoming more luxuriant as we go south but not altering in essential character; so that when we reach the southern extremity of Florida we still find ourselves in the midst of oaks, sumacs, magnolias, vines, and other characteristic forms of the temperate flora; while the birds, insects, and land-shells are almost identical with those found further north. But if we now cross over the narrow strait, about fifty miles wide, which separates Florida from the Bahama Islands, we find ourselves in a totally different country, surrounded by a vegetation which is essentially tropical and generally identical with that of Cuba. The change is most striking, because there is no difference of climate, of soil, or apparently of position, to account for it." (Island Life, 1880, p. 5.)

Let us examine this statement with some care to see if the facts warrant the assertions and conclusions of the author. But first let me protest against Wallace's habit of contrasting insular faunas with those of continuous land areas, in his efforts to minimize the effects of climate. In most cases the great majority of forms peculiar to an island have no means of reaching the nearest continuous land, but in the present instance, as will be shown later, the proximity of Cuba and the Bahamas to Florida, favored by the direction of the Gulf Stream and the prevalence of hurricanes blowing from the Antilles to the Peninsula, have enabled a multitude of West Indian plants, insects, birds, and even land-shells to reach southern Florida, though the breadth of the strait is an effective bar to the passage of terrestrial mammals and reptiles.

Wallace boldly tells us, without attempt at qualification, that "between frigid Canada and sub-tropical Florida there are less marked differences in the animal productions than between Florida and Cuba." Frigid Canada, in eastern North America, is the home of the Eskimo, polar bear, musk oxen, reindeer, lemmings, marmots, beavers, muskrats, porcupines, wolverines, sables, shrews, star-nosed moles, and several other mammals, comprising in all 20 genera, not one of which occurs in southern Florida.* Florida, on the other hand, is inhabited by opossums, harvest mice, rice-field mice, cotton rats, wood rats, pocket gophers, gray foxes, spotted skunks, big-eared bats, and other forms, representing 13 genera and 5 families of mammals that do not occur in frigid Canada†. In the case of birds, eastern Canada has 26 genera that do not reach Florida, among which may be mentioned ptarmigans, grouse, rough-legged hawks, golden eagles, great gray owls, snowy owls, Acadian owls, hawk owls, three-toed woodpeckers, Canada jays, pine bullfinches, cross-bills, linnets, snow buntings, titlarks, winter wrens, kinglets, and stone chats,‡ while Florida has at least 37 genera that do not reach Canada, among which are quails, turkeys, doves of several genera, vultures, caracaras, kites, barn and burrowing owls, parrots, anis, ivory-billed woodpeckers, chuck-wills-widows, cardinals, blue grosbeaks, yellow-breasted chats, mocking birds, and others.*

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* The following 20 genera of mammals inhabit eastern Canada, but none of them reach southern Florida: *Rangifer, Alce, Ovibos, Tamias, Spermophilus, Arctomys, Castor, Fiber, Arvicola, Evotomys, Phenacomys, Myodes, Cuniculus, Zapus, Erethizon, Thalarctos, Gulo, Mustela, Condylura, Scapanus, Sorex.*

† The following 13 genera of mammals inhabit Florida, but none of them reach "frigid Canada:" *Didelphis, Reithrodontomys, Oryzomys, Sigmodon, Neotoma, Geomys, Urocyon, Procyon, Spilogale, Corynorhinus, Nycticejus, Nyctinomus, Otopterus.* The 5 families are: *Didelphidæ, Geomyidæ, Procyonidæ, Emballonuridæ, Phyllostomatidæ.*

‡ The following 26 genera of birds breed in eastern Canada, but none of them in Florida: *Dendragapus, Bonasa, Lagopus, Archibuteo, Aquila, Scotiaptex, Nyctala, Nyctea, Surnia, Picoides, Sphyrapicus, Perisoreus, Dolichonyx, Pinicola, Loxia, Acanthis, Plectrophenax, Calcarius, Zonotrichia, Junco, Passerella, Anthus, Anorthura, Certhia, Regulus, Saxicola.*

Thirty out of the above 37 genera breed also in the West Indies.

No less than nine Tropical American genera of birds inhabit the subtropical belt of Florida, namely, *Zenaida*, *Geotrygon*, *Starnœnas*, *Rostrhamus*, *Polyborus*, *Crotophaga*, *Euetheia*, *Callichelidon*, and *Cœreba*. The following Antillean species and subspecies occur in the same area and are not known from any point further north: *Colinus virginianus cubanensis*, *Columba leucocephala*, *Zenaida zenaida*, *Geotrygon martinica*, *Starnœnas cyanocephala*, *Rostrhamus sociabilis*, *Falco dominicensis*, *Speotyto cunicularia floridana*, *Polyborus cheriway*, *Crotophaga ani*, *Coccyzus minor maynardi*, *Agelaius phœniceus bryanti*, *Euetheia bicolor*, *Euetheia canora*, *Progne cryptoleuca*, *Petrochelidon flava*, *Callichelidon cyanoviridis*, *Vireo altiloquus barbatulus*, *Cœreba bahamensis.* In addition to these species, the following are restricted, so far as known, to southern Florida: *Meleagris gallopavo osceola*, *Chordeiles virginianus chapmani*, *Cyanocitta cristata florincola*, *Ammodramus nigrescens*, *Vireo noveboracensis maynardi*, *Geothlypis trichas ignota*, *Thryothorus ludovicianus miamensis*, *Cistothorus marianæ*, *Sitta carolinensis atkinsi.*

That there are corresponding differences among insects is evident from an important paper by Mr. E. A. Schwarz on the Insect Fauna of Semitropical Florida. Mr. Schwarz states: "I have come to the conclusion that it [the semitropical fauna of Florida] is entirely of West Indian origin, and that the region I shall hereafter circumscribe as Semitropical Florida does not contain any endemic forms. In other words, the distinctive fauna of southern Florida is a permanent colony of West Indian forms, much more numerous in species than it has

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*The following 37 genera of birds breed in Florida, but none of them range north to "frigid Canada," though 30 out of the 37 are known to breed in the West Indies: *Colinus*, *Meleagris*, *Columba*, *Zenaidura*, *Zenaida*, *Columbigallina*, *Geotrygon*, *Starnœnas*, *Cathartes*, *Catharista*, *Elanoides*, *Elanus*, *Ictinia*, *Rostrhamus*, *Polyborus*, *Strix*, *Speotyto*, *Conurus*, *Crotophaga*, *Campephilus*, *Antrostomus*, *Aphelocoma*, *Icterus*, *Peucæa*, *Pipilo*, *Cardinalis*, *Guiraca*, *Euetheia*, *Certhiola*, *Protonotaria*, *Helinaia*, *Helmitherus*, *Icteria*, *Mimus*, *Harporhynchus*, *Thryothorus*, *Polioptila*.

hitherto been supposed, the number in *Coleoptera* alone amounting, according to a very low estimate based upon my collection, to at least 300 species not yet in our catalogues." (Entomologica Americana, IV, No. 9, 1888.) Since the above was published, Mr. Schwarz has had the kindness to inform me that this semitropical insect fauna of southern Florida comprises in all not less than 1,000 species of West Indian or Antillean insects (of which about half are *Coleoptera*), and 50 genera of *Coleoptera* and *Heteroptera* alone;* hence the total number of genera must be very considerable.

Among the Mollusca, Dr. Wm. H. Dall informs me that 20 species or specific types of Antillean land shells are known to inhabit southern Florida, representing 13 genera or subgenera not found further north.†

So far as vegetation is concerned, the case is even stronger, there being upwards of 350 genera of plants in Florida that do not inhabit Canada; and Professor Charles S. Sargent, in speaking of the trees of southern Florida, states: "A group of arborescent species of West Indian origin occupies the narrow strip of coast and islands of southern Florida. * * * This semitropical forest belt reaches Cape Malabar on the east coast and the shores of Tampa Bay on the west coast. * * * The species of which it is composed here reach the extreme northern limit of their distribution; they are generally small, stunted, and of comparatively little value. Certain species, however, attain re-

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*Mr. Schwarz has kindly given me the following list of families of Central American Coleoptera, indicating the number of genera in each family known to inhabit Semitropical Florida, but not found elsewhere in North America: *Carabidæ*, 2 genera; *Phalacridæ*, 1; *Coccinellidæ*, 1; *Cucujidæ*, 1; *Mycetophagidæ*, 1; *Elateridæ*, 1; *Scarabæidæ*, 2; *Cerambycidæ*, 5; *Chrysomelidæ*, 4; *Tenebrionidæ*, 3; *Monommidæ*, 1; *Otiorhynchidæ*, 1; *Curculionidæ*, 6; *Brenthidæ*, 1 [this is the only genus which reappears at Cape San Lucas]; *Calandridæ*, 3; *Scolytidæ*, 3; *Authribidæ*, 2. He informs me also that 11 genera of Tropical American Heteroptera have been found in the same belt.

†The forms here referred to are: *Strobila hubbardii* Brown; *Helix cæca Helix varians* Mke.; *Bulimulus multilineatus* Say; *Bulimulus dormani* W. G. B.; *Orthalicus undatus* Brug; *Liguus fasciatus* Müller; *Liguus fasciatus* var. *Stenogyra gracillima* Pfr.; *Stenogyra subula* Pfr.; *Macroceramus gossei* Pfr.; *Macroceramus pontificus* Gld. (also occurs in Texas); *Strophia incana* Binn.; *Auricula pellucens* Mke.; *Tralia minuscula* Dall; *Melampus* (*Detracia*) *bulloides* Mont.; *Pedipes mirabilis* Muhlf.; *Pedipes elongatus* Dall; *Planorbis tumidus* Pfr.; *Sphœrium cubense* Morelet.

spectable proportions: the mahogany, the mastic, the royal palm, the mangrove, the sea-grape, the Jamaica dogwood, the manchineel, and other species here become considerable and important trees." (Forests of North America, 10th Census, 1884, p. 6.)

From what has been said it appears not only that Wallace's statement that "between frigid Canada and subtropical Florida there are less marked differences in the animal productions than between Florida and Cuba" is wholly incorrect, but that there exists in Florida a well marked subtropical fauna and flora consisting in the main (except in the case of terrestrial mammals and reptiles which could not reach it) of genera, and largely of species, identical with those of Cuba. This being the case, is it not fair to turn the tables and ask Wallace what constitutes the barrier that so effectually holds back hundreds of genera and a multitude of species of Antillean or Tropical American plants, insects, land mollusks, and birds now inhabiting subtropical Florida? The deep arm of ocean between Florida and Cuba or the Bahamas has proved ineffectual in checking their dispersion. What is the more potent barrier that prevents their northward spread along the continuous land of the peninsula? The answer is summed up in the single word *climate*. The temperature of the period of growth and reproduction in the northern parts of Cuba and the Bahamas is the same as in subtropical Florida, but to the northward it falls off rapidly.

Respecting Wallace's statement that the difference between the faunas and floras of hot and cold countries "is by no means constant," and does not bear "any proportion to difference of temperature," it need only be said that no phenomenon of nature is more constant, and that the differences observed depend directly upon temperature. President D. S. Jordan has said: "In many groups anatomical characters are not more profound or of longer standing than are the adaptations to heat and cold." (Popular Science Monthly, XXXVII, Aug., 1890, p. 506.)

That "life is distributed in circumpolar zones, which conform with the climatic zones, though not always with the parallels of the geographer" is a law recognized by Humboldt, Wagner, Agassiz, Dana, De Candolle, Allen, and nearly all writers on distribution except Wallace. This law does not imply that the same species, genera, or higher groups recur under the same degree of heat in disconnected land areas—a manifest impossibility—but that well marked zones of animal and plant life are encountered in all parts of the earth in passing from the poles to the tropics; that they owe their existence to constant differences of temperature, and that in continuous land areas each zone may be traced completely across such areas [from ocean to ocean in those of continental magnitude], following the windings of the belts of equal temperature during the period of reproductive activity.

Wallace speaks thus of this law as formulated by Allen: "The author [J. A. Allen] continually refers to the '*law of the distribution of life in circumpolar zones*,' as if it were one generally accepted and that admits of no dispute. But this supposed 'law' only applies to the smallest detail of distribution—to the range and increasing or decreasing numbers of *species* as we pass from north to south, or the reverse; while it has little bearing on the great features of zoological geography—the limitations of groups of *genera* and *families* to certain areas." (Geog. Dist. of Animals, vol. I, 1876, p. 67). Mr. Allen has already pointed out the weakness of this criticism (Bull. U. S. Geol. and Geog. Survey Terr., vol. IV, No. 2, May, 1878, 326), and I would like to add a word respecting the extraordinary statement that circumpolar distribution affects *species* only, having "little bearing" on the "limitations of groups of genera and families." In refutation of this fallacy it is hardly necessary to do more than call attention to the circumstance that the transcontinental Sonoran region of North America is distinguished from the Boreal by the possession of 7 families and 34 genera of mammals alone,* and the North American Tropical from the Sonoran by 10 families and upwards of 50 genera; while the American Boreal differs from the Eurasian Boreal by the possession of but a single family and only 8 genera.

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* These genera are: *Didelphis, Dicotyles, Cariacus, Antilocapra, Cynomys, Reithrodontomys, Onychomys, Oryzomys, Sigmodon, Neotoma, Geomys, Thomomys, Dipodomys, Perodipus, Microdipodops, Perognathus, Heteromys, Felis, Urocyon, Procyon, Bassariscus, Taxidea, Conepatus, Mephitis, Spilogale, Notiosorex, Scalops, Corynorhinus, Euderma, Antrozous, Nycticejus, Molossus, Nyctinomus*, and *Otopterus*. Five of these genera have each a species reaching a short distance into the southern edge of the Boreal Region, namely, *Cariacus, Neotoma, Felis, Procyon*, and *Mephitis*.

MOUNTAINS AS BARRIERS TO DISPERSION.

Wallace makes the surprising statement that on the two sides of the Rocky Mountains in America "almost all the mammalia, birds, and insects are of distinct species"*—a statement that is wholly untrue, as has been long known to American naturalists. In another place he makes the general statement that mountains, "when rising to a great height in unbroken ranges, form an impassable barrier to many groups." No instance of this kind is known in North America. Even in the High Sierra in California nearly all of the families, genera, and species occur on the east slope as well as on the west, notwithstanding the great altitude this lofty range maintains for a considerable distance.† The explanation of the similarity or identity of the species on the two sides of all our mountain systems is that similar or identical climatic zones occur on both sides, between which avenues of communication exist or have existed by means of passes, either through the ranges themselves or at one end or the other. In their continuity, however, lofty mountain ranges do act as barriers to the spread of species from lower levels, but they do so *indirectly* by their effects upon climate—by interposing an arctic zone in which the species of lower latitudes cannot live. On the other hand, this same arctic-alpine climate enables many polar species to thrive in regions two or three thousand miles south of their normal continental homes.

The great Himalaya has little or no influence in bringing about the really enormous differences that exist between the faunas and floras of the plains on its two sides, for these dissimilarities are due primarily to the great difference of temperature resulting from unequal base-level, the Thibetan plateau on the north being several thousand feet higher than the plain on the south.

THE SO-CALLED EASTERN, CENTRAL, AND WESTERN PROVINCES AND THE EVIDENCE ON WHICH THEY ARE BASED.

Wallace, in common with most recent writers, divides the United States into Eastern, Central or Rocky Mountain, and

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* Geog. Dist. of Animals, I, 1876, p. 6.

† For 320 kilometers (200 miles) the Sierra Nevada Mountains maintain an elevation of 3,100 to 4,600 meters (12,000 to 15,000 feet).

Pacific or Californian 'subregions.' He admits that the Eastern division is characterized by but a single mammalian genus, namely, the star-nosed mole (*Condylura*).

In characterizing the so-called Central or Rocky Mountain subregion, he states that the prong-horned antelope, the mountain goat, the mountain sheep, and the prairie dog are peculiar to it, forgetting that the antelope ranges from the Mexican plateau northward over the Great Plains and Great Basin, and westward over much of California; that the mountain goat inhabits British Columbia and the Cascade Range as well as the Rocky Mountains; that the mountain sheep is common in the High Sierra in California and ranges northward to the Arctic Circle in Alaska; leaving the prairie dog as the only one confined to the region.

The Pacific or 'Californian subregion' he defines as "the comparatively narrow strip of country between the Sierra Nevada and the Pacific. To the north it may include Vancouver's Island and the southern part of British Columbia." Under the head of the mammalia of this area, he enumerates 8 genera as "not found in any other part of the Nearctic region," namely, *Macrotus*, *Antrozous*, *Urotrichus*, *Neosorex*, *Bassaris*, *Enhydra*, *Morunga*, and *Haploodon*. A more erroneous statement could hardly be made. Of the two pelagic genera, *Morunga* and *Enhydra* [= *Latax*], the former does not enter the region at all and the latter barely reaches it; while of the non-pelagic genera three, *Macrotus* [= *Otopterus*], *Antrozous*, and *Bassaris* [= *Bassariscus*], range over the Sonoran region from Texas and the Mexican plateau across New Mexico, Arizona, and parts of southern Nevada and California; and the subgenus *Neosorex* occurs over pretty much the whole of Boreal America from the Atlantic to the Pacific. The two remaining genera only are confined to the Californian division, namely, *Urotrichus* [=*Neurotrichus*] and *Haploodon* [=*Aplodontia*]. Both are isolated types, inhabiting the Pacific coast country from northern California to British Columbia (the latter having no near relative in any part of the world, the former closely related to genera now living in Eastern Asia).

Hence it appears, so far as the mammalia are concerned, that these three supposed primary subdivisions of North America rest upon a misconception of fact, the *Californian* division possessing two peculiar genera, and the *Eastern* and *Central* divisions but a single peculiar genus each—a quantity of difference it would be absurd to recognize as of sufficient weight to warrant the erection of zoogeographical divisions.

In a communication already referred to (North American Fauna, No. 3, September, 1890) I stated the conclusion that the commonly accepted division of the United States into Eastern, Middle, and Western Provinces had no existence in nature, and that "the whole of extratropical North America [the Nearctic region of Sclater and Wallace] consists of but two primary life regions, a *Boreal* region, which is circumpolar; and a *Sonoran* or *Mexican Table-land* region which is unique." The so-called Eastern Province is mainly of Sonoran derivation, comprising the humid divisions of the Lower Sonoran and Upper Sonoran Zones (Austroriparian and Carolinian faunas), and of the Transition or Neutral Belt commonly known among ornithologists as the Alleghanian fauna. It contains also a southward extension of the Boreal Region along the Appalachian mountain system—mainly in the form of isolated islands.

The so-called Central Region in like manner is made up of a southward extension of the Boreal Region along the Rocky Mounain plateau, enclosed between two northward prolongations of the arid Sonoran, the one occupying the Great Plains, the other the Great Basin.

The so-called Pacific or Western Province consists of a southward extension of the Boreal Region which finally bifurcates, sending a long arm south over the Cascade Range and the Sierra Nevada, and a secondary and shorter arm along the Pacific coast north of San Francisco, together with a Sonoran element which covers nearly the whole southern part of the state and reaches north in the San Joaquin and Sacramento Valleys.

PALÆARCTIC AND NEARCTIC REGIONS.

It is no part of the purpose of the present address to discuss the distribution of life outside of our own continent, but it so happens that the Boreal element in America resembles that of Eurasia so closely that in the judgment of many eminent authorities the two constitute but a single primary region—a view in which I heartily concur. This arrangement is antagonistic to that proposed by Sclater* in 1857 and adopted with slight modification by Wallace. Sclater considers the whole of extratropical North America as constituting a single region, upon which he bestowed the name *Nearctic*, in contradistinction to the corresponding part of Eurasia, which he named *Palæarctic*, believing the two to be distinct primary regions.

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*Journ. Linn. Soc. (Zool.), II (for 1857), 1858, 130–145; and again, with some alterations, in Ibis, sixth series, III, 1891, 514–557.

Wallace, the great champion of Sclater's Palæarctic and Nearctic regions, says of the former in his most recent work on geographic distribution: "Taking first the mammalia, we find this region is distinguished by its possession of the entire family of *Talpidæ* or Moles, consisting of 8 genera and 16 species, all of which are confined to it except one which is found in Northwest America, and two which extend to Assam and Formosa." (Island Life, 1880, 41.) How he could have made such an erroneous statement is hard to understand, in view of the well-known fact that three genera of moles inhabit eastern North America and two the Pacific coast region; and it is the more strange since on another page of the same work he states that there are three peculiar genera of moles in North America.*

He states further: "Among carnivorous animals the lynxes (9 species) and the badgers (2 species) are peculiar to it [the Palæcrctic region] in the old world, while in the new the lynxes are found only in the colder regions of North America" (Island Life, 1880, 41), thus implying that there are no badgers in North America, and ignoring the presence of lynxes all along the southern border of the United States from Florida and Texas to southern California. Continuing, he mentions a number of groups which, he says, "have only a few species elsewhere." Among these are the "voles, dormice, and pikas." Pikas inhabit the mountains of western Canada and range south in the Cascades and High Sierra to southern California, and in the Rocky Mountains to Colorado. They have been reported also from the high mountains of Lower California in Mexico. The group of voles or *Arvicolinæ*, exclusive of the lemmings, is represented in Boreal North America by not less than 4 genera, 5 subgenera, and nearly 50 species. It is only fair to add, however, that some of these have been described since Wallace's book was written

"The Nearctic region is so similar to the Palæarctic in position

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*In his earlier work he says: "*Condylura* (1 species), the star-nosed mole, inhabits eastern North America from Nova Scotia to Pennsylvania; *Scapanus* (2 species) ranges across from New York to San Francisco; *Scalops* (3 species), the shrew moles, range from Mexico to the Great Lakes. * * * *Urotrichus* is a shrew-like mole which inhabits Japan, and a second species has been discovered in the mountains of British Columbia." (Geog. Dist. of Animals, II, 1876, 190.)

and climate," he admits, "and the two so closely approach each other at Bering Strait, that we cannot wonder at there being a certain amount of similarity between them—a similarity which some naturalists have so far overestimated as to think that the two regions ought to be united." After enumerating a number of mammals common to the two he goes on to say: "We undoubtedly find a very close resemblance between the two regions, and if this were all, we should have great difficulty in separating them. But along with these we find another set of mammals, not quite so conspicuous but nevertheless very important. We have first, three peculiar genera of moles, one of which, the star-nosed mole, is a most extraordinary creature, quite unlike anything else. Then there are three genera of the weasel family, including the well-known skunk (*Mephitis*), all quite different from eastern forms. Then we come to a peculiar family of carnivora, the raccoons, very distinct from anything in Europe or Asia; and in the Rocky Mountains we find the prong-horned antelope (*Antilocapra*) and the mountain goat of the trappers (Aplocerus [=*Mazama*]), both peculiar genera. Coming to the rodents, we find that the mice of America differ in some dental peculiarities from those of the rest of the world, and thus form several distinct genera; the jumping mouse (*Xapus* [=*Zapus*]) is a peculiar form of the jerboa family; and then we come to the pouched rats (*Geomyidæ*), a very curious family consisting of four genera and nineteen species, peculiar to North America, though not confined to the Nearctic region. The prairie dogs (*Cynomys*), the tree porcupine (*Erethizon*), the curious sewellel (*Haploodon* [=*Aplodontia*]), and the opossum (*Didelphis*) complete the list of peculiar mammalia which distinguish the northern region of the new world from that of the old." (Island Life, p. 48.)

As already shown in an earlier part of the present essay, most of these genera and several of the families belong to the austral or Sonoran region and have no place in the Boreal fauna—the only one that can be compared with the fauna of northern Eurasia. As a matter of fact, 81 genera of non-pelagic mammals are now recognized in 'extratropical' North America—the so-called Nearctic Region. Of this number 41 are found in no other part of the world.* These genera are enumerated in the following table, which brings out the important fact that no less than 32, or 78 percent, are of Sonoran or austral origin, while only 9, or 22 percent, are of Boreal origin. Of these 9 genera now confined to North America, *Ovibos* inhabited polar Eurasia in Pleistocene times; *Neurotrichus* is not recognized by Flower and Lydekker as more than subgenerically separable from *Urotrichus* of Japan, and *Synaptomys* is not known except from the Transition Zone of the United States and is here classed as Boreal because of its close relationship to the transcontinental Boreal genus *Myodes*. Omitting these three, Boreal North America has but 6 genera of mammals not known from Boreal Eurasia.

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* The intrusive genera *Didelphis*, *Tatusia*, *Dicotyles*, *Procyon*, *Nasua*, and *Molossus*, which are clearly of South American origin, are not here included.

Peculiar Genera of Mammals inhabiting North America north of Mexico

Of Boreal Origin

Mazama
Ovibos
Aplodontia
Fiber
Synaptomys
Zapus
Erethizon
Neurotrichus
Condylura

Of Sonoran Origin

Cariacus
Antilocapra
Cynomys
Reithrodontomys
Sitomys
Oryzomys
Onychomys
Sigmodon
Neotoma
Thomomys
Geomys
Dipodomys
Perodipus
Microdipodops
Perognathus
Heteromys
Urocyon
Bassariscus
Taxidea
Conepatus
Mephitis
Spilogale
Notiosorex
Scalops
Scapanus
Blarina
Antrozous
Nycticejus
Otopterus
Corynorhinus
Euderma
Atalapha

On the other hand, out of the 31 Boreal genera of North American mammals the following 24 genera, or 77 percent, are common to Boreal America and Boreal Eurasia:

Cervus
Rangifer
Alce
Ovis
Bison
Tamias
Arctomys
Castor
Phenacomys
Evotomys
Arvicola
Myodes

Cuniculus
Lagomys
Vulpes
Ursus
Thalarctos
Latax
Lutreola
Putorius
Mustela
Gulo
Sorex
Urotrichus *

In addition to the foregoing genera, which are clearly of Boreal origin, the following 12 genera of more extended range are also common to the two continents:

Sciuropterus
Sciurus
Spermophilus
Lepus
Canis
Lutra

Felis
Lynx
Vesperugo
Vespertilio
Plecotus†
Nyctinomus

Most of these genera are known to be of great antiquity, their remains having been found in Miocene strata, and it is probable that the others belong to the same category, but have thus far escaped detection, owing to their very small size. All of them attain their maximum development and numbers in the Sonoran Region in America and the analogue of the Sonoran in Eurasia; but by reason of the great length of time that has elapsed since they came into existence some of their representatives have become acclimated to a wide range of climatic conditions.

Dr. John L. Le Conte, in his report on the Coleoptera of Lake Superior, said: "The entomologist cannot fail to be struck with two very remarkable characters displayed by the insect fauna of these northern regions. First, the entire absence of all those groups which are *peculiar* to the American continent [*i. e.*, Sonoran and Tropical groups]. * * * The few new genera which

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*As stated above, Flower and Lydekker do not recognize the American animal as generically distinct from *Urotrichus*. While I agree with Dobson in according it generic rank, it is convenient, in studying the origin of groups, to bring together such closely related types.

†The American species of *Plecotus* are separated generically by Dr. Harrison Allen under the name *Corynorhinus*, which is adopted by the writer. The more comprehensive name *Plecotus* is here used for the reason just stated under *Urotrichus*.

I have ventured to establish are not to be regarded as exceptions. They are all closely allied to European forms, and by no means members of groups exclusively American.

"Secondly, the deficiency caused by the disappearance of characteristic forms is obviated by a large increase of the members of genera feebly represented in the more temperate regions, and also by the introduction of many genera heretofore regarded as confined to the northern part of Europe and Asia. Among these latter are many species which can be distinguished from their foreign analogues only by the most careful examination. This parallelism is sometimes most exact, running not merely through the genera, but even through the respective species of which they are composed." (Lake Superior, 1850, 239–240.)

W. F. Kirby, in a paper 'On the Geographical Distribution of the Diurnal Lepidoptera as compared with that of Birds,' states: "Had I been dealing with Lepidoptera only, I would certainly have united Dr. Sclater's 'Palæarctic Region' and 'Nearctic Region;' for although the species of North American Rhopalocera are seldom identical with those of northern Asia and Europe, still the genera are the same with scarcely an exception, except a few representatives of South American genera, which have no more right to be considered Nearctic species than the similar chance representatives of African forms in North Africa or Southwest Europe, or of Indian forms in Southeast Europe, have to be considered Palæarctic species." (Journ. Linnean Soc. London, Zool. 1873, 432.)

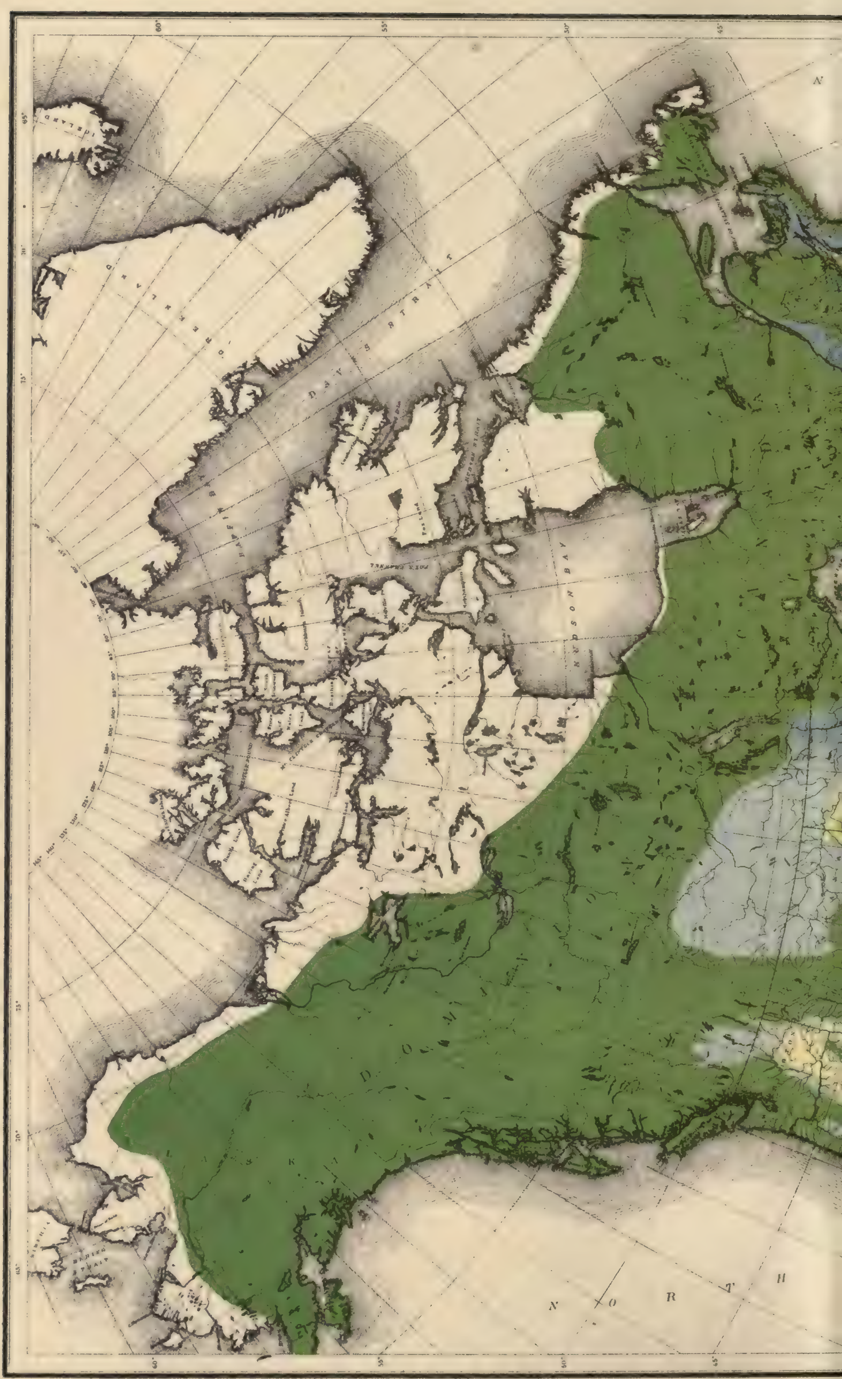
It now becomes evident that the so-called Palæarctic and Nearctic regions are the result, in each case, of confounding and combining two wholly distinct regions—the Boreal with the Sonoran in America and the Boreal with the analogue of the Sonoran in Eurasia. Eliminating these austral elements as wholly foreign to the region to which they have been so persistently attached, there remains a single great Circumpolar Boreal region characterized by a remarkably homogeneous fauna, covering the northern parts of America and Eurasia.

Cope has shown that the chief differences between Boreal America and Boreal Eurasia are found among the fishes and batrachians—animals living wholly or in part in water. Now it cannot be insisted too strongly that while the chief factor in the distribution of aquatic animals and plants is temperature, as has been long acknowledged, yet from the very nature of the case the resulting life regions must be different—the one supplementing or being the complement of the other—for water being the medium in which the species live, the bodies of water with their prolongations and extensions, as bays, rivers, and lakes, must be studied as entities, just as we study a continent with its peninsulas and outlying islands—the means of access to a given body of water being the principal factor in determining the water-area to which its aquatic life belongs. And it should be remarked that aquatic mammals, as seals and cetaceans, and aquatic birds, as ducks and gulls, conform in the main to the laws and areas of aquatic distribution and should not be taken into account in studying the distribution of terrestrial forms of life.

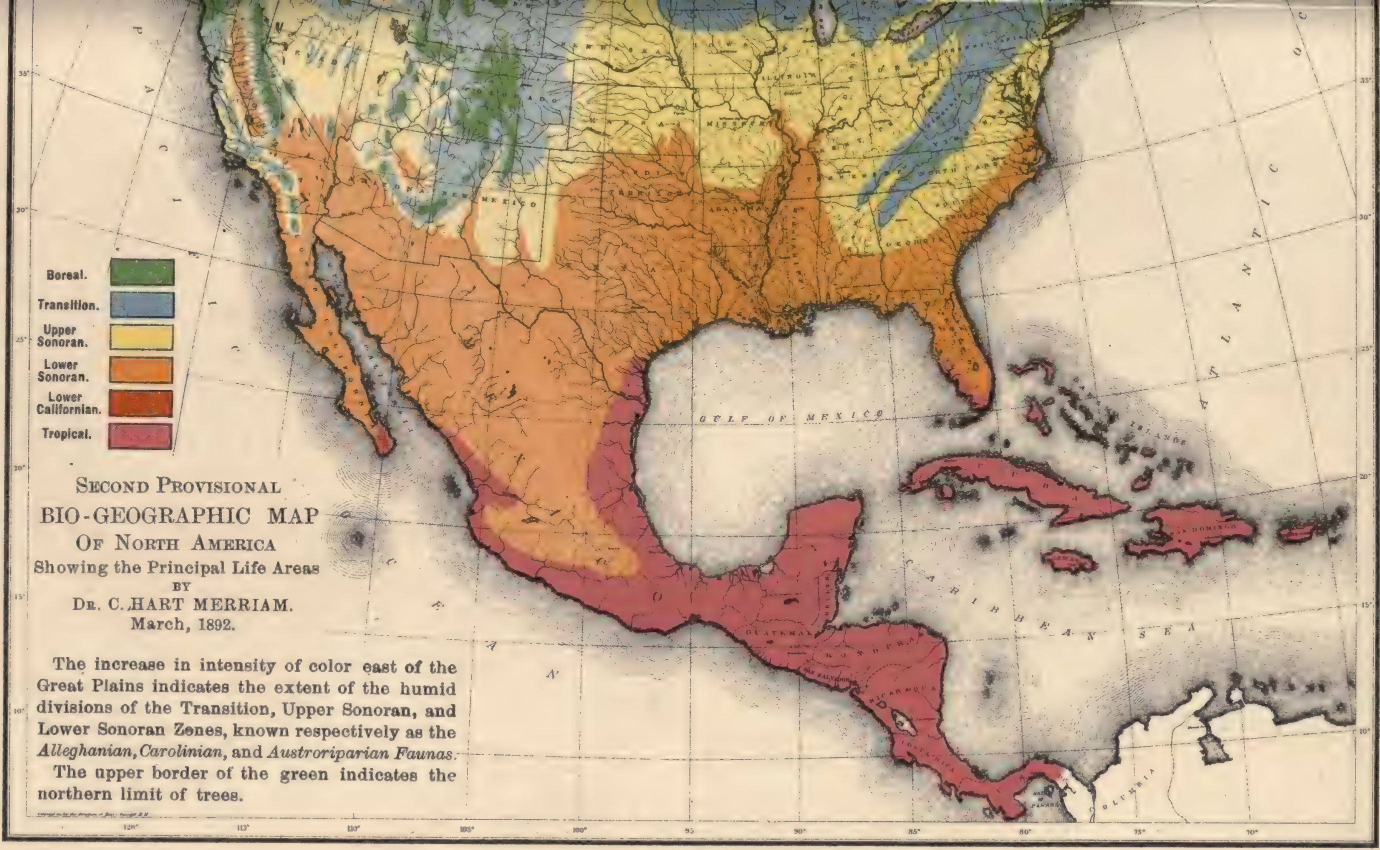
Gill has said with much truth: "There appears to be a total want of correlation between the inland and marine faunas, and a positive incongruity, and even contrast, between the two." (Proc. Biol. Soc. Wash., II, 1884, 32.)

PRINCIPLES ON WHICH BIO-GEOGRAPHIC REGIONS SHOULD BE ESTABLISHED.

Wallace, in writing of the principles on which Zoological regions should be formed, expresses the opinion that "convenience, intelligibility, and custom, should largely guide us." But I quite agree with America's most distinguished and philosophic writer on distribution, Dr. J. A. Allen, that in marking off the life regions and subregions of the earth, truth should not be sacrificed to convenience; and I see no reason why a homogeneous circumpolar fauna of great geographic extent should be split up into primary regions possessing comparatively few peculiar types simply because a water separation happens to exist in the present geologic period; nor is it evident why one of the resulting feeble divisions should be granted higher rank than a region of much less geographic extent comprising several times as many peculiar types. Hence the divisions here recognized, and the rank assigned them, are based as far as possible upon the relative numbers of distinctive types of mammals, birds, reptiles, and plants they contain, with due reference to the steady multiplication of species, genera, and higher groups from the poles toward the tropics. Mammals have been chiefly used as illustrations because they answer the purpose better than any other single group, and because it is clearly impossible in a brief essay of this character to enumerate such a multitude of forms as would be necessary were equal consideration accorded to each class.



ICELAND
GREENLAND
DAVIS STRAIT
BAFFIN BAY
HUDSON STRAIT
Cumberland Island
Fox Land
FOX CHANNEL
Southampton
Melville
Cockburn Island
Boothia
Prince of Wales Land
Victoria Land
Prince Albert Land
Banks Land
Baring Land
HUDSON BAY
DOMINION
NORTH
BEHRING STRAIT
60°
55°
50°
45°
70°
75°
65°



Boreal.
Transition.
Upper Sonoran.
Lower Sonoran.
Lower Californian.
Tropical.
GULF OF MEXICO
CARIBBEAN SEA
ATLANTIC OCEAN
PACIFIC OCEAN
CUBA
BAHAMA ISLANDS
SAN DOMINGO
GUATEMALA
HONDURAS
SAN SALVADOR
NICARAGUA
COSTA RICA
COLUMBIA
NEBRASKA
IOWA
ILLINOIS
KANSAS
MISSOURI
COLORADO
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
FLORIDA
35°
30°
25°
20°
15°
10°
120°
115°
110°
105°
100°
95
90°
85°
80°
75°
70°

SECOND PROVISIONAL
BIO-GEOGRAPHIC MAP
OF NORTH AMERICA
Showing the Principal Life Areas
BY
DR. C. HART MERRIAM.
March, 1892.

The increase in intensity of color east of the Great Plains indicates the extent of the humid divisions of the Transition, Upper Sonoran, and Lower Sonoran Zones, known respectively as the *Alleghanian, Carolinian,* and *Austroriparian Faunas.*

The upper border of the green indicates the northern limit of trees.

Photo-Lith. by A. HOEN & CO., Balto., Md.

VOL. VII, PP. 65-80 MAY, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTIONS OF NEW PLANTS FROM SOUTHERN CALIFORNIA, NEVADA, UTAH, AND ARIZONA.

BY FREDERICK VERNON COVILLE.*

In January, 1891, an expedition was sent out by the United States Department of Agriculture to make a biological survey of Death Valley, in southeastern California, and the adjacent regions. As several months must elapse before the report on the botany of the expedition can be presented to the public, the following descriptions of new plants are now published with the consent of the department authorities.

Aplopappus interior sp. nov.

Related to *A. linearifolius* DC., but differing in its shorter leaves (12 to 20 mm.), subulate-bracteate peduncles, shorter acute involucral bracts, and smaller rays 9 to 11 mm. long. In *A. linearifolius* the larger leaves are 30 to 40 mm. long, the peduncles leafy-bracted, the involucral bracts 11 to 14 mm. long, including the filiform-subulate acumination, and the rays 13 to 15 mm. long.

Type specimen in the United States National Herbarium, No. 794, Death Valley Expedition; collected May 20, 1891, about four miles southeast from Mill Cañon divide, at the northern edge of the Darwin Mesa, Inyo County, California, by Frederick V. Coville.

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* Presented at a meeting of the Biological Society of Washington, April 16, 1892.

A. linearifolius, first collected in California by Douglas, probably near San Francisco or Monterey, is known only from the coast ranges southward from San Francisco bay. *A. interior* is a species of the desert mountains, and has been collected in the higher elevations of the Lower Sonoran region from southern Utah, northwestern Arizona, and Inyo County, California, southward to the extra-coastal region of San Diego County.

Arctomecon merriami sp. nov.

Plant apparently perennial, from a thick woody root, branching into a broad cæspitose tuft 10 cm. or less high; leaves cuneate-oblanceolate, 2 to 3 cm. long, tapering below into a margined petiole, tridentate at the truncate apex, glaucous, clothed with very long (about 1 cm.), white, spreading, flexuous, barbellate hairs; upper leaves sessile, often entire and acute or obtuse at the apex; peduncles several, erect, 20 to 35 cm. high, glabrous, glaucous, rarely with a bract (similar to the leaves) below; flower single, in bud inclined to nod; sepals usually 3, hairy like the leaves, caducous; petals usually 6, white, obcordate, 3 to 3.5 cm. long, deciduous; stamens very numerous; anthers 3 to 4 mm. long when wet; filaments slender, glabrous, some of them conspicuously broader above; ovary narrowly oblong, 1-celled, with 6 or 7 parietal placentæ; style about 1.5 mm. long and broad; stigma capitate and with a stigmatic line opposite each placenta; capsule linear-oblong, in our specimens 3.5 to 4.1 cm. long; valves splitting down at the apex for a distance of 8 mm.; seeds not seen.

Type specimen in the United States National Herbarium, No. 1890, Death Valley Expedition; collected May 1, 1891, a few miles west of Vegas ranch, Lincoln County, Nevada, by C. Hart Merriam and Vernon Bailey.

This plant differs from *A. californicum* it its usually 1-flowered bractless peduncles, long-hairy sepals, white petals, longer dilated filaments, linear-oblong ovary and capsule (4 cm. long), and evident style. *A. californicum* has, on the other hand, 6- to 20-flowered, leafy-bracted peduncles, glabrous sepals, deep yellow petals, filaments of uniform width, obovoid ovary, sessile stigma, and an ovate capsule about 1.5 cm. long.

This beautiful poppy is dedicated to Dr. C. Hart Merriam as a token of his influence in the progress of geographic botany.

Arctomecon humile sp. nov.

In 1874 Dr. C. C. Parry collected in the vicinity of St. George, Utah, an *Arctomecon*, which Dr. Gray referred* to *A. californicum.* The material now in hand shows that it is distinct both from the original plant of Fremont and from the species just described. It differs from the former in its smaller size throughout, less hairy leaves, fewer flower parts, white petals, dilated filaments, and the presence of a style; from *A. merriami* in its smaller size and more scanty hairs, more than 1-flowered peduncles, fewer flower parts, persistent petals, and obovate, several times shorter capsule.

Type specimen in the Harvard Herbarium.

The genera *Canbya* and *Arctomecon* are described† as distinguishable by their stigmas; in the former opposite the placentæ, in the latter opposite the valves. In *Arctomecon merriami* the capitate stigma is evidently made up of as many parts or lobes as there are placentæ, and each of these parts is directly opposite a valve. Along both lateral margins of each lobe are stigmatic lines, and the union of the two contiguous ones, of adjacent lobes, makes a stigmatic line opposite the placenta. There is nothing in *Canbya* to show that the stigmatic line, which is there also opposite the placenta, was not derived in the same way; yet the two genera are sufficiently characterized by their general differences.

Arenaria compacta sp. nov.

Stems compacted into a dense mat from a thick, woody, many-branched caudex, the densely leafy lower portion 1 cm. or less high; flowering stems scantily leafy, sparingly cymosely branched, 5 cm. or less high, clothed with short glandular hairs; leaves awl-shaped, triangular in cross-section, pungent, glandular-ciliate, 5 mm. or less long, squarrose; those of the flowering stems similar, usually glandular-hairy on the back, erect, passing into scarious bracts above; flowers single, terminating simple stems, or in open few-flowered cymes; sepals 5, 2.5 to 3.5 mm. long, ovate to ovate-lanceolate, scarious-margined, with a thick green midrib excurrent into a point; petals 5 or 6, oblong-oblanceolate, broadly obtuse; stamens 10 to 12; styles 3 or 4.

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* Proc. Amer. Acad. Sci., XII, 1877, 53, pl. II.

† Idem, XII, 1877, 52, and XXII, 1887, 270.

Type specimen in the United States National Herbarium, No. 1653, Death Valley Expedition; collected August 20, 1891, at timber-line on a divide northwest of Whitney Meadows, Sierra Nevada, Tulare County, California, by Frederick V. Coville.

The plant is of especial interest because it is evidently a local alpine species derived not from the circumpolar *Arenaria biflora* and *A. arctica*, but from some local species of a lower zone, similar to *A. fendleri*. Its sepals distinguish it at once from the circumpolar plants mentioned above, in which these organs are thin, striate, and obtuse. In habit, however, it closely resembles them, having attained the depressed, matted, shrubby form so protective to plants at high altitudes.

Brickellia desertorum sp. nov.

Shrubby, about 1 m. high; branches minutely white-tomentose, becoming glabrous in the second or third year, but still with a white epidermis, afterward gray; leaves alternate, minutely cinereous-tomentose; petioles 2 to 5 mm. long; blades deltoid ovate, truncate at the base, crenate-dentate, commonly 3 to 8 mm. long, on vigorous shoots reaching 16 mm. in length; heads in glomerules of 2 to 4 flowers, on short leafy branches from a main axis, or in the second or third year the branches elongated and divaricate and bearing a single terminal glomerule; involucre 7 to 8 mm. high, about 10- to 12-flowered; bracts 3-nerved, with traces of minute tomentum, 1 mm. or less wide, bluntly acute, the outermost oblong-lanceolate, all widely recurved after the maturing of the achenia; achenia 2 mm. long, sparingly short hispid; pappus scabrous.

This plant differs from *B. californica* in its more shrubby branches, whiter stems, much smaller canescent leaves, and heads smaller throughout. In *B. californica* the involucres are commonly 10 to 12 mm. long and the bracts obtuse, while the achenia are 3 mm. long.

Type specimen in the United States National Herbarium; collected November 7, 1889, between Banning and Seven Palms, on the Southern Pacific Railroad, California, by C. R. Orcutt.

The type specimen of *B. californica* was collected by Douglas probably near San Francisco or Monterey. That species is known in the coast region of California from Mendocino county as far south at least as San Diego. Specimens from Utah and Arizona have been referred to *B. californica* only with doubt. The new species is known only from the Colorado and Mohave Desert regions. It shows close relationship, too, with the type form of *B. reniformis*, but differs from it, as from *B. californica*, in canescence and size of leaves, heads, and achenia.

Buddleia utahensis sp. nov.

Shrub 20 to 30 cm. high, young branches leaves and calyces densely tomentose; leaves linear to narrowly linear-oblong, irregularly crenate, with undulate revolute margins, conspicuously venose-reticulate, 1.5 to 2 cm. long, reflexed or divaricate on petioles 1 to 2 mm. long, with smaller leaves axillary-fasciculate; inflorescence made up of 2 to 4 distinct spheroidal congested clusters (about 1.5 cm. in diameter and about the same distance apart) of flowers spicately arranged at the extremities of the branches; bracts subtending the clusters similar to the leaves, the uppermost much smaller; calyx lobes 1-nerved; corolla in dried specimens brownish purple, weathering to straw color, tube tomentose without, lobes widely spreading; anthers sessile in the throat of the corolla.

This plant is closely related to *B. marrubiifolia*, but is readily distinguished by its spicate flower clusters and narrow leaves. In that species the single sperical head terminates the branches upon a well defined peduncle, while the leaves vary from ovate to obovate with cuneate base.

Type specimen in the United States National Herbarium; collected in 1877 near St. George, southern Utah, by Edward Palmer.

The plant has been collected but twice, once in the type locality and now at the foot of a limestone cliff just north of Mountain Spring, near Olcott Peak, Charleston Mountains, Nevada. The former is the most northerly locality known for any species of the genus. *B. marrubiifolia* is known in the United States only in southern Texas.

Erigeron calva sp. nov.

Apparently biennial, widely branching from the base, 1 cm. high, sparingly canescent with hirsute pubescence; radical leaves very numerous, blade oblong to obovate, 1 to 1.5 cm. long, tapering into a petiole of twice that length; upper leaves spatulate, becoming much smaller; heads singly pedunculate on the branches, 7 to 8 mm. high, hemispherical, with very many flowers; involucral bracts narrowly linear, acuminate, hirsute; ray flowers numerous, but with rays minute, pink, and shorter than the disk; pappus of ray and disk flowers alike, consisting of several long, stout, closely barbellate bristles (4 mm. long), equalling the disk corollas, and a few intermediate much shorter ones; achenium compressed, short villous.

This species resembles in general appearance no described *Erigeron.* Its heads closely resemble those of *E. supplex,* but that species has no ray flowers whatever. Its pubescence is similar to that of *E. concinnus.* The specific name refers to the bald appearance of the heads, due to the minuteness of the rays.

Type specimen in the United States National Herbarium, No. 870, Death Valley Expedition; collected May 16, 1891, at the foot of the Inyo Mountains, about four miles north of Keeler, California, by Frederick V. Coville.

Erysimum asperum perenne Watson, var. nov.

Apparently perennial, the old stem-base horizontal or nearly so; stem erect, 25 to 50 cm. high; radical leaves oblong to oblanceolate, entire or very sparsely denticulate-dentate, tapering into a long petiole, sparsely strigose (like the stem) with the pick-shaped hairs of *E. asperum;* stem leaves narrowly oblanceolate; petals light yellow; fruit wanting.

Type specimen in the United States National Herbarium, No. 1487, Death Valley Expedition; collected August 5, 1891, between Mineral King and Farewell Gap, Sierra Nevada, Tulare County, California, by Frederick V. Coville.

Dr. Watson, in answer to my letter (forwarded to him with the specimens) saying that this plant appeared distinct from *E. asperum* and similar to *E. pumilum* of Nuttall, determined the plant questionably as a new variety of *E. asperum*, and sent the following note: " This may be distinct, but it is impossible to define a new species from this material. It has not the habit of '*E. pumilum*,' which is a very dubious species. Its perennial character, as your specimens show, is not always obvious, and our other high mountain specimens from California and elsewhere do not help to distinguish it from *E. asperum.*" The plant differs conspicuously from the ordinary Californian form of *E. asperum* in its yellow instead of orange petals, perennial rootstock, smaller size, less canescent herbage, and broader root-leaves, and, furthermore, in its geographic range at a uniformly higher altitude, above the belt of *Pinus jeffreyi*, to which, with that of *Pinus ponderosa*, the former appears to be confined.

Frasera tubulosa sp. nov.

Plant a biennial or short-lived perennial, in our specimens about 60 cm. high; stem stout, terete, glabrous, glaucous, about 6 mm. thick at the base; radical leaves in a dense rosette, linear-oblanceolate, obtuse, mucronate, reaching 1 cm. in width and 9 cm. in length, usually conduplicate and the apex recurved, thick, minutely scabro-puberulent, glaucous in appearance, its margin white, cartilaginous, entire; stem leaves similar, becoming smaller above, in whorls of 5 or 6; inflorescence a narrow spicate panicle 30 to 40 cm. long, interrupted below, its branches reaching 5 cm. in length, mostly shorter, erect; pedicels 2 to 20 mm. long, erect; sepals 4, linear-subulate, 6 to 8 mm. long, often spinulose-denticulate toward the base; petals 4, white, oblong-obovate, acuminate, 9 to 11 mm. long, slightly gibbous at the base; gland on the face of the petal none, but represented by a tube of the same texture, and half as long, as the corolla, inserted over the gibbosity at the base of the petal, split about half way to the base in a direction tangential to the axis of the flower, the posterior lobe slightly larger and both lacerate-fimbriate; stamens 4, filaments about as long as the sepals, anthers oval, 2 mm. long; ovary compressed, oblong-lanceolate, tapering into 2 subulate appressed styles, the whole equalling the stamens; placenta at the edges of the ovary, not intruded; ovules 6 to 10, oblong, very thin and flat; stigmas recurved-spreading, flat, hardly broader than the style; capsule very flat; valves obovate-oblong, with callous thickened margins and 1 median nerve continued into the stiff subulate persistent style, the whole 12 to 14 mm. long; seed single, lamelliform, oblong, minutely cellular-muriculate, about 5 to 7 mm. long.

This plant differs from all other species of the genus in the apparent absence of the petaline gland and in the presence of the tubular nectary described above. The leaves are very similar to those of *F. albomarginata*, while the form of the inflorescence resembles that of *F. nitida* and *F. albicaulis.*

Type specimen in the United States National Herbarium, No. 1598, Death Valley Expedition; collected August 17, 1891, in dry soil under *Pinus jeffreyi* in the northeast corner of the enclosure at Soda Springs, on the north fork of Kern River, Sierra Nevada, Tulare County, California.

Gilia setosissima punctata var. nov.

Flowers and fruit larger than in the type form; corolla with tube about 10 mm. long, its lobes 7 to 10 mm. long, white, with purple dots sometimes arranged in longitudinal lines, and a pair of golden spots at about the middle; capsule 6 to 9 mm. long, often with 10 seeds in each of the 3 cells.

The plant differs from the type form in the characters above mentioned. In *G. setosissima* the corolla tube has about the same length, but the lobes are much smaller (3 to 5 mm. long) and cream-colored, with neither purple nor yellow markings, and the capsule is commonly about 5 mm. long with about 5 seeds in a cell. This variety holds the same relation to the type form that *G. matthewsii* does to *G. schottii*, except that in the case of the latter two species the differentiation appears to be complete, while in the former integrades in size and coloration occur. The flowers of *G. setosissima* and its variety are regular, erect, and with straight stamens, while those of the other two species are irregular, inserted at an angle or even horizontally, and have ascending stamens. In herbarium specimens this irregularity is often obscured, and *G. schottii* is frequently confounded with *G. setosissima*. Both *G. schottii* and *G. matthewsii* are, however, readily distinguishable from *G. setosissima* and its variety by a vegetative-character which was originally pointed out* by Watson, but which was afterward lost sight of. In the former the lateral bristles of the leaf arise singly, in the latter in twos (rarely singly or in threes), from each hair tubercle. This character is constant.

These four plants are very interesting from the standpoint of their genealogical interrelation. The parent form probably was, or was very similar to, *G. setosissima*; from this *G. schottii* developed; and then, from both these, plants with larger, strikingly colored corollas differentiated, *G. setosissima punctata* and *G. matthewsii* respectively. The name adopted for the variety is one used on herbarium specimens by Dr. Gray but never published.

Type specimen in the United States National Herbarium, No. 716, Death Valley Expedition; collected April 21, 1891, in Surprise Cañon, Panamint Mountains, California, by Frederick V. Coville.

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* Bot. King Surv., 1871, 267.

Isomeris arborea globosa var. nov.

Stem not glaucous; petals ovate, sub-palmately veined; capsule globose, truncate or retuse, 2.5 to 3.5 cm. long; seed with a transverse groove between hilum and body; otherwise as the type form.

Our plant differs conspicuously from the type form in the shape of its capsules, a character at once noticeable in the living plant. The stems of the new year's growth in the type form are glaucous; the petals narrowly oblong and pinnately veined; the capsules oblong, attenuate into the stipe, abruptly tapering at the apex; and the seeds without a groove between the hilum and the body. The same plant as ours, but without mature fruit, was collected by Xantus de Vesey near Fort Tejon in 1857–58.

Type specimen in the United States National Herbarium, No. 1107, Death Valley Expedition; collected June 24, 1891, on Caliente Creek, a few miles above Caliente, Kern County, California, by Frederick V. Coville.

The characteristic distribution of this variety was not ascertained. It might be expected to be a form modified by proximity to the Mohave Desert, but the type form enters the western portion of this desert in at least one place, Tehachapi Pass; and flowering specimens, presumably of the type form, were seen in April about forty miles from Mohave on the road from that place to Searles' borax establishment.

Lepidospartum striatum sp. nov.

Shrub 1 to 1.6 m. high, with a stout erect trunk; branches numerous, erect, striate-angled by 3 ribs decurrent from each leaf-base, closely white-tomentose, the ribs resiniferous and glabrous; leaves alternate, filiform-linear, thicker above, acute, slightly spreading, 20 to 25 mm. long, or the upper only 10 mm.; heads 2 to 5 at the apex of the branch, singly sessile, or very short-peduncled, in the axils of leaf-like bracts, 12 to 16 mm. long; involucre oblong to narrowly oblong, 7 to 10 mm. high; bracts about 9, broadly ovate to narrowly oblong, obtuse, stiff, coriaceous, with narrow membranaceous margin, lanate on the back, imbricated, the outer successively shorter; flowers 5; corolla lobes linear-lanceolate, acute, longer than the throat, with marginal nerves and an oblong or linear resin duct at the apex; anthers acutely sagittate at the base; anther-tips obtuse; styles 2 to 2.5 mm. long, linear, bluntly acute but short-hairy so as to appear obtuse; achenium densely villous with spreading long white hairs; pappus copious, white, of conspicuously scabrous soft bristles.

This plant has the general appearance of a *Tetradymia*, but the involucre and style-tips of *Lepidospartum*. The branches resemble those of *T. glabrata*, except that the decurrent leaf-base is made up of three slender ribs instead of one broad line. The leaves too are very similar to the primary ones of that species. The involucral bracts are thoroughly imbricated, and in this respect are quite different from those of any *Tetradymia;* yet their texture and pubescence are the same. The pappus and achenia closely resemble those of *T. glabrata* and *T. canescens inermis.* The median nerve of the corolla lobes in *Tetradymia* and in *Lepidospartum squamatum*, which are really resin ducts, are here reduced to large linear or oblong apical resin glands not produced to the base of the lobe. The anther tip is really acute but from the hairs about it appears obtuse, and somewhat resembles that of *Tetradymia.* The plant forcibly suggests the reuniting of *Lepidospartum* with *Tetradymia*, as a subgenus, a position in which Dr. Gray* once placed it, but the involucres of the two genera are of quite different types.

Type specimen in the United States National Herbarium, No. 558, Shockley, 1888; collected in August, 1888, in Soda Springs Cañon, Esmeralda County, Nevada, by W. H. Shockley.

Mentzelia reflexa sp. nov.

Plant annual, 20 cm. or less high; stem stout, diffusely branching from the base, brownish white and striate when dry, hirsute, as well as the leaves and calyx lobes, with retrosely barbed, as well as with upwardly denticulate, hairs; leaves from linear-oblanceolate below to ovate or even hastate above, short-petioled or sessile, all irregularly sinuate-dentate or the lowest almost pinnatifid; flowers single on short usually 1- or 2-leaved axes in the forks of the stem; ovary broadly oblong, 4 to 5 mm. long, hirsute; calyx lobes triangular-subulate, about 1.5 mm. broad at base by 5 to 6 mm. long; petals oblong-oblanceolate, tapering to a bluntly acute apex, equalling the calyx lobes; staminodia none; stamens 9 to 13, shorter than the calyx; filaments expanded at base only, or almost to the apex, to a width of about .5 mm.; anthers small, about as broad as long; placentæ 3, broad, fleshy; ovules about one-half imbedded in the placentæ; style cleft for about one-third its length, equalling the stamens; capsule oblong, 8 to 10 mm. long, its pedicel reflexed at the apex; seeds about 10 or 12 in each capsule, gray, somewhat compressed, angularly obovate or pyriform, slightly constricted below the middle, and with a deep transverse groove on either face along this line, muriculate throughout.

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* Proc. Amer. Acad. Sci., IX, 1874, 207.

This plant appears not to be closely related to any known species of *Mentzelia.* It resembles in its petals, stamens, and seeds *M. torreyi*, and in the last of these organs *M. tricuspis* and its allies. Its characteristic external features are its diffusely branched but stiff habit, its flowers scattered in the forks of the stem, and its reflexed fruiting pedicels. Its seeds resemble those of *M. tricuspis.*

Type specimen in the United States National Herbarium, No. 709, Death Valley Expedition; collected April 21, 1891, in Surprise Cañon, Panamint Mountains, California, by Frederick V. Coville and Frederick Funston.

Phacelia perityloides sp. nov.

Suffrutescent perennial 10 to 20 cm. high, diffusely branched, densely leafy; stem, as well as branches, leaves, and calyx, viscid with glandular hairs, or at the base densely villous-tomentose; leaves alternate; petiole 7 to 15 mm. long; blade orbicular with truncate to cordate base, crenate-dentate or even lobed, 7 to 12 mm. in diameter, the hairs shorter than on the stem and petiole; flowers in loose racemes terminating the branches; pedicels 3 to 5 mm. long; calyx about 4 mm. long, the lobes oblong-spatulate, obtuse; corolla cream-white, sparingly glandular-hairy, twice as long as the calyx, its narrowly campanulate tube longer than the calyx and its short orbicular lobes abruptly spreading; appendages 10 semilanceolate vertical lamellæ free from the filaments; the 3 veins of each corolla lobe continuing distinct to the base of the tube; stamens included in the throat of the corolla; anthers oblong; ovary and included style sparingly short hairy; style tips very short, divergent; capsule narrowly ovate, bluntly acute, 3 to 4 mm. long; seeds apparently very numerous, oblong, angulate by compression, scrobiculate, 5 mm. long.

The plant closely resembles a small congested specimen of *Perityle emoryi.* The form of the leaves is very similar to that in *P. rotundifolia*, but the plant, while belonging to the subgenus *Eutoca*, differs from all its species in being suffrutescently perennial. The cream-white corollas form another conspicuous character.

Type specimen in the United States National Herbarium, No. 524, Death Valley Expedition; collected March 31, 1891, in Johnson Cañon, Panamint Mountains, California, by Frederick V. Coville.

Potentilla eremica sp. nov.

Plant of the sub-genus *Ivesia*, perennial, in large tufts from a branched caudex, villous-canescent throughout; stems few, erect or procumbent, 10 to 20 cm. high, sparingly short-leafed; radical leaves many, the largest 13 cm. long, terete; leaflets sometimes 60 pairs, entire, broadly ovate, acute or obtuse, 2 to 2.5 mm. wide, closely imbricated in 2 rows along the rachis; stem leaves similar, shorter, borne at intervals of about 1 to 2 cm., the uppermost not exceeding 1 cm. in length; cyme narrow, about 5 cm. long; bracts simple or few-cleft, about 3 mm. long; pedicels 5 to 7 mm. long, erect; calyx 3 to 4 mm. long, lobes lanceolate-acuminate; calyx bracts ovate; stamens 20; pistils apparently 2 or 3; hairs of the receptacle dense, conspicuous, 1 to 1.2 mm. long.

This plant was collected in winter, so that only the remains of the inflorescence of the preceding year were found. The leaves at first sight closely resemble those of *P. santolinoides.* The plant was found in but one place, about two miles east of Watkins' ranch (and about one-half mile south of the "devil's hole"), in an alkaline limestone marsh on a sloping gravelly mesa, growing with *Spartina gracilis*, *Anemopsis californica*, and *Schœnus nigricans.*

Type specimen in the United States National Herbarium, No. 366, Death Valley Expedition; collected March 2, 1891, near Watkins' ranch, Ash Meadows, Nye County, Nevada.

Potentilla purpurascens pinetorum var. nov.

Plant cæspitose from a many-branched caudex; stems about 3 cm. high; inflorescence loosely cymose; radical leaves very numerous, 7 to 14 cm. long; lower leaflets about 7 mm. long, 2-divided, the divisions often 2-lobed; upper leaflets merely 2-lobed; divisions in both oblong-oblanceolate, glabrous or very scantily villous; otherwise as the type form.

In aspect our plant is quite different from Rothrock's specimens of the type form,* they being but 5 to 16 cm. high, with shorter leaves, and shorter, broader, more congested, villous-hirsute leaflets. The characters of the flowers are identical. The following references to *Potentilla purpurascens* may be helpful: Wats. Proc. Amer. Acad. XI 148 (1876) under *Horkelia;* Greene, Pittonia I 105 (1887).

Type specimen in the United States National Herbarium, No. 1579, Death Valley Expedition; collected August 10, 1891, at Trout Meadow, Sierra Nevada, Tulare County, California, by Frederick V. Coville.

Our plant was abundant throughout the valley of the north fork of Kern River, in forests of *Pinus jeffreyi*, along the rather dry margins of meadows. Rothrock's came from a higher altitude, 9,000 feet, "on the head-waters of Kern River," and is undoubtedly a derivative form modified by changed conditions.

Sarcobatus baileyi sp. nov.

Shrub .5 to 1 m. high; bark dark gray after the first year; branches divaricate, closely interlocking, the ultimate banchlets always spinescent; leaves 8 to 14 mm. long or shorter, pubescent, especially near the apex, with short, flattened, branched, reflexed hairs, the later leaves often glabrate in age; male spike not seen; fertile spikes infra-axillary on old wood, consisting of 2 female flowers at the base (one often wanting), each in the axil of a leaf, and a terminal spiciform portion of male flowers, the whole axis 1 to 1.5 cm. long; fruit very large; body 8 to 9 mm. long, about 5 mm. broad at its widest point; wing oblong-orbicular, erose, 10 to 15 mm. by 8 to 10 mm. in diameter; seed not developed.

The plant differs from *S. vermiculatus* in its smaller size, always spinescent branchlets, intricate and compact growth, smaller and usually pubescent leaves, larger fruit, and different inflorescence. *S. vermiculatus* usually grows, in Nevada, 1.2 to 1.8 m. high, with branches less intricate and often not spine-tipped, and leaves when well developed 12 to 20 or even 30 mm. long and almost invariably glabrous. Its fertile flowers are described by Bentham and Hooker* as axillary and solitary, but the axis on which they are borne is really continued into a rudimentary male spikelet similar to that of *S. baileyi*, but each floral axis, instead of bearing 1 or 2 female flowers as in that species, commonly has from 4 to 8. In *S. vermiculatus* the body of the fruit is 4 to 5 mm. long, 2.5 to 3.5 mm. broad, and the wing 7 to 13 mm. by 5 to 8 mm. in diameter.

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*Bot. Wheeler Surv., 1876, pl. III.

Type specimen in the United States National Herbarium, No. 1994, Death Valley Expedition; collected June 2, 1891, in a valley near Thorpe's quartz-mill, Nye County, Nevada, by Vernon Bailey.

The plant was first seen by Mr. Bailey at Cloverdale, Esmeralda County, Nevada, in 1890, and recognized by him as different from *S. vermiculatus.* In company with Dr. Merriam he afterward found it in a valley in Nye County, Nevada, southeast by east from Gold Mountain, near Thorpe's quartz-mill, and later in Fish Lake Valley westward from the other localities, on the California state line. There is in the National Herbarium a specimen of the same plant collected by J. G. Lemmon in 1875, probably in western Nevada. The species is therefore confined, so far as known, to the counties of Esmeralda and Nye, in Nevada, and Mono and Inyo, in California. I take pleasure in associating Mr. Bailey's name with this shrub, both as a mark of his earnest and invaluable labors in the field of natural history and as a reminder of a warm friendship established among the vicissitudes of a desert exploration.

Saxifraga integrifolia sierræ var. nov.

Blades of larger leaves 8 to 12 cm. long, oblong-lanceolate to elliptical-lanceolate, acute, conspicuously serrate-denticulate, from glabrous to sparingly clammy-hairy above and beneath, thinner and more distinctly veined than in the type; petiole and margin of the leaf toward the base ciliate with clammy hairs; otherwise as the type form.

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* Gen. Pl. III, 1880, 76.

Type specimen in the United States National Herbarium, No. 1705, Death Valley Expedition; collected August 25, 1891, about eight miles northwest of Whitney Meadows, on the headwaters of Kern River, Sierra Nevada, Tulare County, California, by Frederick V. Coville.

The species was described* from specimens collected by Scouler "near the mouth of the Columbia, northwest coast of America," and is excellently figured.† Specimens collected in later years in the same region agree with Hooker's description and figure in being viscid-pubescent throughout, and in having the leaves oblong, entire, obtuse, and scarcely exceeding 3.5 cm. in length. None of the specimens from the Sierra Nevada resemble the type form, but a good series of intergrades exist between the two regions and in the Rocky Mountains where the variety occurs also.‡ The Sierran plant appears never to have been described except in the Botany of California, where the description of the type form is varied to include it. In Dr. Gray's conspectus of the species of Saxifraga § it is not distinguished from Hooker's plant.

Stylocline arizonica sp. nov.

Plant of the subgenus *Eustylocline*, 5 cm. or less high; habit that of *S. micropoides*; leaves obtuse or abruptly acute; heads 4.5 to 6 mm. high; bracts of the receptacle broadly winged around the conduplicate portion; achenium lunate.

The species differs from *S. micropoides* in its prevailingly obtuse leaves, its winged bracts, and its lunate achenia; that species having narrowly acute leaves, bracts not produced into wings at the margin, and straight achenia. From *S. gnaphaloides* it differs in its smaller size, larger heads, and linear-oblong leaves. *S. gnaphaloides* attains a height of 8 to 10 cm. and is very diffusely branched, while its heads are seldom more than 3 mm. high and its leaves are oblanceolate with a tapering base.

Type specimen in the United States National Herbarium; collected May 1, 1867, on the Verde Mesa, Arizona, by Dr. Charles Smart.

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* Hook. Fl. Bor. Amer., I, 1833, 249.

† Loc. cit., t. 86.

‡ Wheeler Survey, No. 796.

§ Proc. Amer. Acad. Sci., XX, 1884, 8–12.

The species undoubtedly is confined to the Lower Sonoran zone of the desert region. *S. gnaphaloides* belongs to the intramontane region of California.*

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* The word "intramontane" is applied here to that portion of California west of a line of mountains made up of the Sierra Nevada, San Bernardino, and San Jacinto ranges, together with their connecting ridges. That area is thus distinguished from the ultramontane or desert and Great Basin portions of the state. The two regions are marked by distinct characteristic floras. North of the Sierra Nevada and south of the San Jacinto Mountains the precise location of the dividing line has not been clearly determined.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

SOME INTERRELATIONS OF PLANTS AND INSECTS.*

BY C. V. RILEY, PH. D.

It is my purpose to-night to present some phases of the curious interrelations between plants and insects. In doing this I shall not have time to deal with the remarkable series of results that have followed the more careful and accurate investigation of the so-called insectivorous or carnivorous plants, and which have shown that these plants are not only possessed of the power of movement depending upon nerve stimuli, that may be likened in almost every respect to the automatic movements of animals, but that they actually possess digestive powers and properties which, chemically and functionally, are the same as those by which animals digest their food. It is my desire rather to call your attention to certain phases of plant fertilization by insects.

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*This communication was presented for the most part extemporaneously, with the aid of stereopticon views. In preparing it, by request, for the printer, I have assumed that the facts already published in reference to Yucca pollination are familiar to the members of the Society, and have presented in the briefest manner such only as throw light on the philosophical portion of the article. The descriptive portion is condensed from a more extended paper recently prepared for the Annual Report of the Missouri Botanical Garden, but not yet published, and the illustrations are for the most part borrowed in advance from that paper. Figures 8, 10, 11, 12, and 13, however, are from my previous publications; Figure 6 was prepared specially from the stereopticon slide; and Figures 2, 3, and 4 are from the Department of Agriculture and used by permission of Assistant Secretary Willits.

I need not tell the members of this Society that the old idea that flowers were endowed with beauty and fragrance for our particular pleasure has been effectually set aside, and that these attributes have come to be looked upon in their true light, as essential to the plant's existence and perpetuation; that, in other words, color, form, odor, secretions, and the general structure of flowers, all have reference to insects. Nor need I dilate on the need of cross-fertilization in plants generally, or the modification which insect pollinizers have undergone as a consequence of this need. Some of the more interesting facts are particularly well exemplified in our orchids, to the philosophic study of which Darwin's important work "On the Fertilization of Orchids" gave a distinct impulse. But here we have adaptation of the plant only, and, with scarcely an exception, most flowers, including those of our orchids, may be fertilized by different insects. There are, in fact, few which are dependent on a single species for pollination, and, so far as I know, our Yuccas furnish the only instance of this kind. It is to the fertilization of these plants that I would first draw your attention.

The Yuccas are a characteristic American group of liliaceous plants, finding their home more particularly in the southern United States and Mexico. There are many species which have been divided even into sub-genera by Dr. Engelmann, as Sarcoyucca, Clistoyucca, Chenoyucca, and Hesperoyucca; but for our present purpose they may all be included under the one genus Yucca, as they all possess certain characteristics in common, viz, a thick, sub-mucilaginous root, which is in reality a subterranean stem; lance-shaped, evergreen leaves, narrow or broad, rigid or flaccid, and with the edges either filamentose, smooth, or more or less distinctly serrate. The leaves produce a coarse fiber, valuable for certain kinds of fabrics, while the trunks of the tree Yuccas have been used to make the toughest kind of paper. The fruit of some species, as of *aloifolia* and *baccata*, is fleshy and edible. It is, however, the flowers to which I would draw more especial attention. They are produced in large panicles, and are characterized as a rule by the anthers not reaching anywhere near the stigma; so that fertilization unaided can take place only by the merest accident. The Yuccas show great variation in detail, both in leaf, general habitus, flower-stalk, flower, and fruit, from the common sessile *Yucca filamentosa* of our gardens to the arboreal forms, like *brevifolia* of the Mohave Desert and *filifera* of Mexico. My remarks will be based chiefly on *Yucca filamentosa*, which is indigenous to the Southeastern States and is cultivated beyond its natural range, under a number of horticultural variety names, in our gardens.

An examination of the flower will show at once the peculiarities which I have alluded to as characteristic of the genus. The stamens or filaments are bent away from the stigma and do not reach more than two-thirds the length of the pistil, the stigmatic opening being at the tip of the prolonged style and nowhere within reach of the stamens, while the pollen either remains attached to the open and withered anthers or falls in different sized lumps on the underside of the perianth. It cannot be introduced into the stigmatic tube without artificial aid, and the plant depends absolutely on the little white moth belonging to the Tineina and known as *Pronuba yuccasella* Riley.

STRUCTURAL CHARACTERISTICS OF PRONUBA.

Upon a superficial view, this little moth shows nothing very peculiar. The general coloration is white, the primaries being purely white on the upper surface; so that when at rest in the half open flowers of the Yucca it is not easily detected. The under surfaces, however, are dusky and offset in flight the whiteeness of the rest of the body, so as to render the species somewhat difficult of detection while flitting from plant to plant. The male shows no very marked peculiarities to distinguish him from the other members of the family, the most noticeable being, perhaps, the prominence of the exposed parts of the genitalia. The female, however, shows some remarkable structural peculiarities, which admirably adapt her for the functions she has to perform, for she must fertilize the plant, since her larvæ feed upon its seeds.

Now, if I should ask any well-informed entomologist what are the characteristics of the Lepidopterous mouth, in the imago state, he would unhesitatingly answer: The lack of all prehensile organs and a coiled tongue capable of sucking liquids. If again I should ask what distinguishes the Lepidoptera from, say, the Hymenoptera, in the methods of oviposition, he would answer that the Lepidoptera lay eggs possessing, it is true, an infinite diversity of form, but usually attached externally to some part of the food-plant of the species, while the Hymenoptera as a rule secrete theirs, and are furnished with either a puncturing, boring, or sawing instrument for that purpose. The generalization would be entirely justified, though there are many curious exceptions to it, especially in the very group Tineina, to which our Yucca moth belongs. It is, however, necessary to state these general truths in order to convey a just idea of the exceptional nature of the two organs to which I wish more particularly to draw your attention. The first is a pair of maxillary tentacles which are prehensile and spinous on their under surface. They are peculiar to the genus Pronuba and exist in no other genus

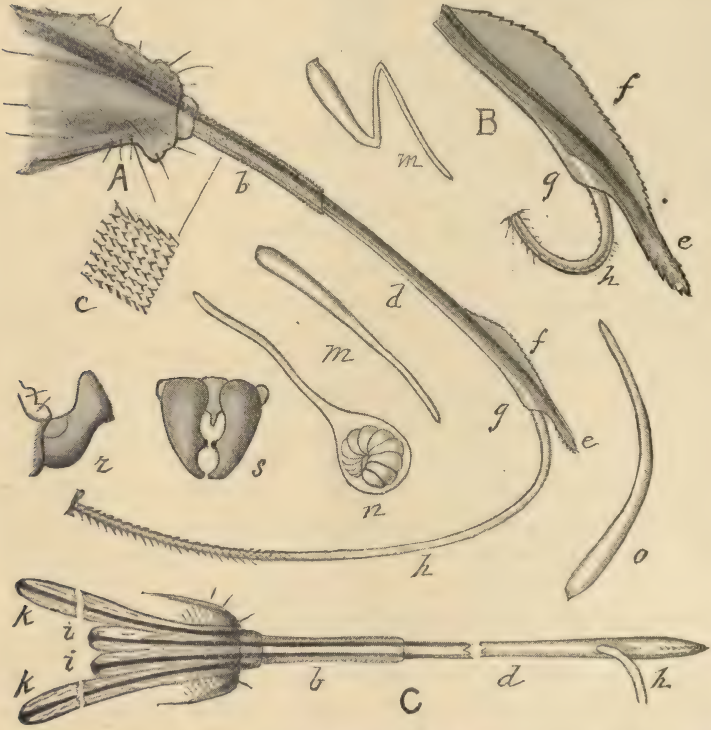

Fig. 1.—A, tip of anal joint and vaginal projection of ♀ *Pronuba yuccasella* from side, showing ovipositor with parts extended; *b*, basal joint; *c*, its file-like surface; *d*, terminal joint, with its dorsal serrate wing (*f*), its dentate tip (*e*), its ventral membranous outlet (*g*), and the extended oviduct (*h*); B, the same parts further enlarged; C, ventral view of tip of abdomen, showing the two pair of rods *i*, *i* and *k*, *k*, with their muscular attachments, the parts of the ovipositor similarly lettered as in A; *m*, *m*, eggs taken from Yucca pistil; *n*, egg, showing development of embryon; *o*, mature egg from ovary of ♀; *r*, *s*, genital claspers of ♂, lateral and dorsal view—all enlarged.

of the many thousands of butterflies and moths.* The other organ is the ovipositor, which, instead of being a simple opening, as typically found in Lepidoptera, is here modified into a complex combination of lance and saw. Ordinarily it is withdrawn and hidden, but when in action is projected far beyond the tip of the abdomen and is then seen to consist of two principal parts the basal part being imbricato-granulate—*i. e.*, having a delicate file-like structure, the terminal part being smooth, but having near the end a dorsal serrate chitinous wing and a still more strongly toothed corneous tip. The internal structure is seen to consist of two stout rods, extending along the thin walls to the very tip, and of a ventral canal or passage-way for the delicate oviduct, which is silk-like and elastic and may be extruded for a great length from an outlet near the end of the ovipositor. This oviduct is smooth basally, but armed along its terminal third with retrorse hairs, increasing somewhat in number and strength toward the tip, around which they are almost spinous. At first sight these would seem to be out of place and to impede rather than aid the insertion of such a delicate filament; but, as we shall presently see, the act of oviposition is a most intricate and difficult one and these hairs are doubtless sensitive and tactile and serve the double purpose of enabling the moth to feel her way in the ovarian cell and of temporarily anchoring in the soft wall thereof while the egg is being passed to its destination. It will be seen that this ovipositor is admirably adapted for cleaving through the young fruit and then running the egg into the ovarian cavity, as will be presently described. The manner in which this ovipositor is worked by the four rods attached to strong muscles is indicated at Fig. 1, C, the two inner rods forming, as already indicated, the rigid portion of the ovipositor proper and the imbricate basal portion of the covering facilitating the invagination of the basal part when the ovipositor is withdrawn. The two outer rods are attached to strong muscular tissue in the walls of the vagina, and when the ovipositor is extended to its utmost limit this vaginal portion is partially extruded so as to appear like a basal subjoint. More detailed characterization of these parts is unnecessary in this connection.

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* There are over 12,000 described species of Lepidoptera from Europe and America, and those from other parts of the world will double this number. Nearly as many more remain, perhaps, to be described.

THE ACTS OF POLLINATION AND OVIPOSITION.

Having thus drawn attention to the most characteristic structures of Pronuba, we shall better understand the following account of the acts of pollination and oviposition which I quote from an article recently prepared for the Annual Report of the Missouri Botanic Garden:

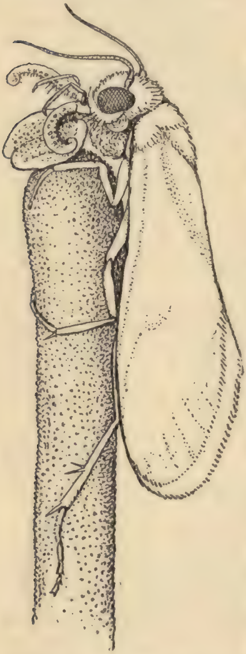

FIG. 2. — Female *Pronuba yuccasella* gathering pollen, × 5.

"Though all the acts of the female are nocturnal, it is not at all difficult to follow them with a lantern, for, albeit ordinarily shy, she may be closely approached when about to oviposit. Her activity begins soon after dark, but consists, at first, in assiduously collecting a load of pollen. She may be seen running up to the top of one of the stamens and bending her head down over the anther, stretching the maxillary tentacles, so wonderfully modified for the purpose, to their fullest extent, the tongue uncoiled and reaching to the opposite side of the stamen. In this manner she is able to obtain a firm hold of the stamen, while the head is kept close to the anther and moved peculiarly back and forth, something as in the motion of the head of a caterpillar when feeding. The maxillary palpi are used in this act very much as the ordinary mandibles are used in other insects, removing or scraping the pollen from the anthers toward the tentacles. After thus gathering the pollen she raises her head and commences to shape it into a little mass or pellet by using her front legs very much as a cat does when cleansing her mouth, sometimes using only one leg, at another time both, smoothing and pressing the gathered pollen, the tentacles meanwhile stretching and curving. After collecting all the pollen from one anther she proceeds to another and repeats the operation, then to a third and fourth, after which, with her relatively large load—often thrice as large as the head—held firmly against the neck and front trochanters, she usually runs about or flies to another plant; for I have often noticed that oviposition, as a rule, is accomplished in some other flower than that from which the pollen was gathered, and that cross-fertilization is thus secured.

"Once fully equipped with this important commodity, she may be seen either crawling over or resting within the flower, generally with the head toward the base. From time to time she makes a sudden dart and deftly runs around the stamens, and anon takes a position with the body between and the legs straddling two of them, her head being usually turned toward the stigma. As the terminal portion of the stamens is always more or less recurved, she generally has to retreat between two of them until the tip of her abdomen can reach the pistil. As soon as a favorable point is reached, generally just below the middle, she rests motionless for a short time, when the abdomen is slightly raised and the lance-like ovipositor is thrust into the soft tissue, held there the best part of a minute, while the egg is conducted to its destination, and then withdrawn by a series of up-and-down motions.

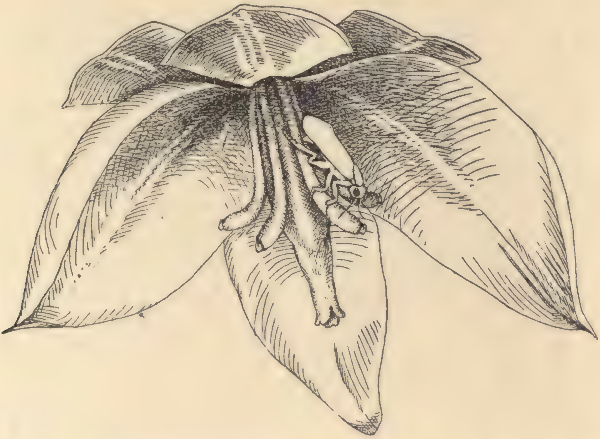

FIG. 3.—Flower of *Yucca filamentosa* with near petals removed, showing Pronuba in act of ovipositing.

"In non-technical language, the pistil or the young fruit, below the stigmatic tube, shows externally at this time six quite distinct longitudinal divisions, each having a median ridge, there being six corresponding depressions or concavities in which the six stamens fit, especially at the base. Technically, the pistil is a three-celled ovary, the styles bifid at tip and united so as to form the stigmatic tube. A transverse section anywhere about the middle will show that each of the six longitudinal sections contains a row of ovules within an ovarian cell. More strictly, the ovules are in pairs, as there are but three primary sections or carpels, divided by three primary divisions or dissepiments. Figure 4 shows a transverse section of one of these primary divisions or carpels which well indicates the position of the ovules (*a*), the funiculus (*b*), the placenta (*c*), and the ovarian cell (*d*). As the fruit enlarges, the three secondary dissepiments narrow and coalesce, while the other three widen, so that the pod becomes practically three-lobed and the seeds are more distinctly in pairs, the inner side straight and the external quite convex. In oviposition the young fruit is pierced just within the ridge in the depression occupied by the stamens, and almost always on the side of one of the primary or deeper divisions, where the walls are thinnest, so that the ovipositor enters the ovarian cell at the external or rounded side of an ovule and does not ordinarily touch the ovule itself. Rarely, however, the ovipositor penetrates the ridge and passes between two of the ovules, or sometimes even penetrates one, this last case being, however, quite exceptional.

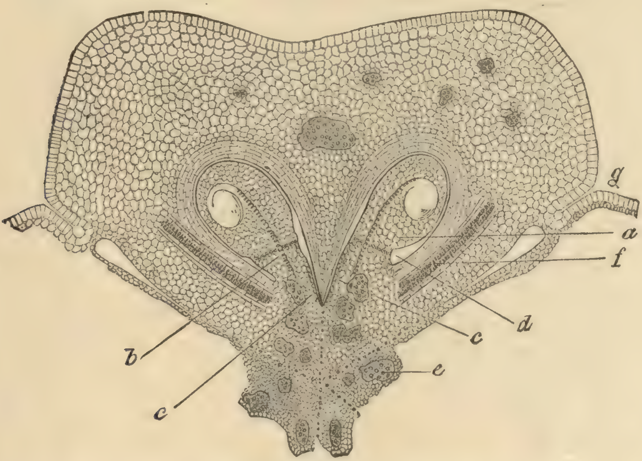

Fig. 4.—Transverse section of one of the carpels of Yucca pistil: *a*, ovule; *b*, funiculus; *c*, placenta; *d*, ovarian cell; *e*, fibro-vascular bundles; *f*, fibro-vascular tissue; *g*, primary dissepiment × 9.

"The egg is an extremely delicate thread-like structure, averaging 1.5 mm. in length and less than 0.1 mm. (Fig. 1, *m*, *n*, *o*) in diameter, tapering at the base and enlarging slightly toward the capitate end, which has also a slightly indurated point. It is impossible to follow it with the unaided eye or in fact with an ordinary lens, even if the pistil be at once plucked and dissected; but by means of careful microscopic sections we may trace its course. From the position assumed by the moth, the ovipositor punctures the pistil somewhat obliquely, but as the egg is much longer than the diameter of the ovarian cell, the delicate oviduct of the moth bends and then runs vertically along the inner part of the cell next the placenta, and leaves the egg extending in this longitudinal direction along some seven or eight ovules, as shown in the illustrations (Fig. 5, *c*, *c*). The apical end of the egg soon enlarges (Fig. 1, *n*), and the embryo may be seen developing in it very much as in the case of the similarly elongate eggs of gall-flies (Cynipidæ), though the pedicel does not shorten, as observed in these last. Segmentation is noticeable on the second day, and the Yucca ovule at once begins to swell and enlarge, the irritation (doubtless mechanical) influencing the plant tissue much as in the case of the punctures of the gall-flies

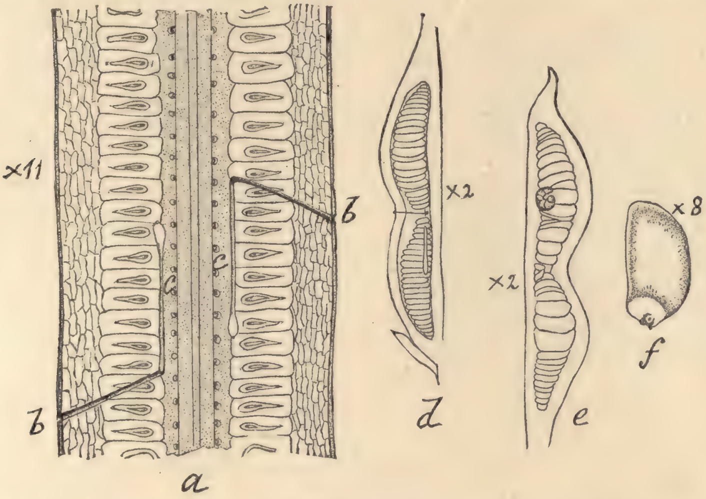

FIG. 5.—*a*, longitudinal section of pistil of *Yucca filamentosa*, showing (*b*, *b*) punctures of Pronuba, and (*c*, *c*) the normal position of her eggs in the ovarian cell; *d*, section of a punctured carpel 7 days after oviposition, showing the egg yet unhatched and the manner in which the ovules in the neighborhood of puncture have been arrested in development so as to cause the constriction; *e*, section of an older carpel, showing the larva above the original puncture; *f*, a seed 13 days from oviposition, showing young larva at funicular base—enlargements indicated.

just mentioned. Sometimes two or more adjacent ovules are thus affected."

It may be well right here to look a little more closely into the minuter characteristics of the Yucca flower at this stage of its development that we may understand more fully the action and influence of the moth. In my first article, published some twenty years ago, announcing the discovery of Pronuba and its action on Yucca pollination, I was strongly inclined to the idea that the act of pollination had some compensating inducement to the moth, aside from the impelling instinct of perpetuation of the species. At that time it was supposed that the stigmatic liquor was nectarian, and the conclusion was justifiable that the moth, attracted to it for feeding purposes, would incidentally induce pollination. On this view of the matter it did not require a great stretch of the imagination to conceive that the pollen might also incidentally accumulate in the spines, and that the vigorous action of the head that had been noticed might even be considered as an effort to get rid of the encumbrance while feeding. In those days I was more imbued with the common notion that lower creatures are impelled for the most part unconsciously to their acts. Twenty years of study and experience have only served to prove the acts of Pronuba the more unselfish and without food inducement. A longitudinal section of the upper portion of the pistil will show the style with the stigmatic tube, which at this time communicates with the ovarian cells. Now, Trelease has shown that the stigmatic liquor is not nectarian, but that the slight amount of nectar associated with the flower is secreted in pockets formed by the partitions that separate the three cells of the pistil, and which open externally near the style by a contracted pore from which the nectar is poured through a capillary tube to the base of the pistil. The accompanying illustration (Fig. 6) renders this more intelligible, *a* being a longitudinal section through the center of a pistil, showing the septal gland (*g*), the duct (*d*), and the outlet at base; *b*, a cross-section of the pistil about the middle, also showing the duct (*d*) and gland (*g*); *c*, a more enlarged cross-section of the nectar apparatus; *e* showing more fully the structure of the septal gland, while *h* is a longitudinal section of the top of the pistil, through the lobes, showing how the stigmatic tube (*s*) connects with the ovarian cell (*o c*), *o* being the ovary, *f* the funiculus, *p* the placenta, and *f v* fibro-vascular tissue.

These interesting facts, which I have fully verified, show that nectar-feeding insects seek it not about the stigma, but at the base of the stamens or of the petals, whether within or without. In short, the nectar in these Yucca flowers has no value in pollination, and Pronuba, in collecting the pollen and transferring it to the stigma, finds no food compensation, a conclusion which is confirmed by a study of the minute structure and internal anatomy of the moth, which indicate that the tongue proper, though strongly developed, has to a great extent, if not entirely, lost its function as a sucking organ, and that the alimentary canal is practically functionless, being aborted before reaching the anus. This defunctionization, if I may use the term, of im-

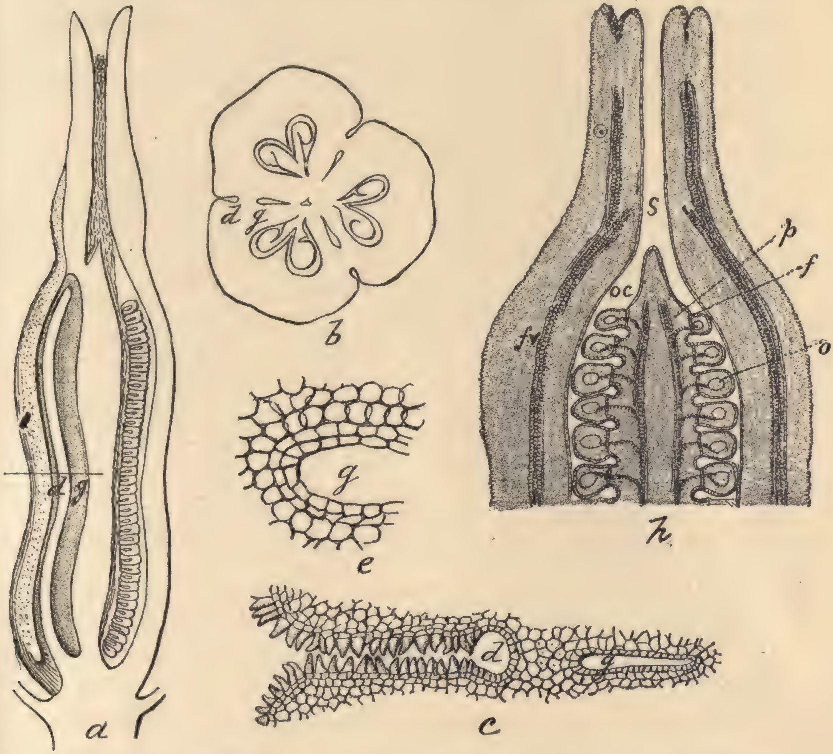

Fig. 6—Nectar apparatus of Yucca: *a*, longitudinal section of pistil, with duct (*d*) and gland (*g*); *b*, cross-section about middle, showing same parts; *c*, still more enlarged cross-section of nectar apparatus; *e*, structure of septal gland—after Trelease; *h*, longitudinal section of top of pistil, showing stigmatic tube (*s*) ovarian cell (*oc*), ovule (*o*), funiculus (*f*), placenta (*p*), and fibro-vascular tissue (*fv*).

portant structures has not proceeded so far in *Pronuba yuccasella* as in *P. maculata*, which pollinizes *Yucca whipplei.* Those not familiar with the structure of Lepidoptera will hardly appreciate the modifications to which I shall allude, however, without the preliminary statement that the tongue in Lepidoptera consists of two distinct parts (maxillæ) which are more or less concave on their inner side and united at the borders of the concave portion by certain locking arrangements to form between them the sucking tube. Now, while in most cases the two parts may be relaxed and separated by force, in nature they are never so separated, while the tip of the tongue is more or less acuminate and the two parts here very firmly united.

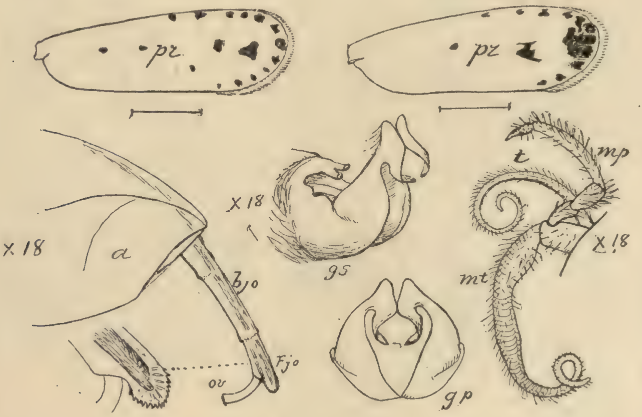

Fig. 7.—Pronuba maculata: *a*, tip of female abdomen; *b j o*, basal joint of ovipositor; *t j o*, terminal joint of ovipositor; *ov*, oviduct; *m p*, max. palpus; *m t*, maxillary tentacle; *t*, tongue; *gs*, claspers of male from side; *gp*, claspers of male from behind—enlargement indicated; *pr*, front wings, showing arrangement of spots in two of the more common forms, hair-lines showing natural size.

In *Pronuba yuccasella* I had often noticed that the two parts became separated and in fact were almost always separated toward the tip, thus suggesting a loss of function as a sucking organ, but otherwise the tongue is strongly developed, and, with the exception of the weakness of the locking arrangement, not particularly abnormal. In *Pronuba maculata*, however (Fig. 7), the two parts of the tongue are but very feebly united, and often more or less disconnected, and are actually thickly covered with minute hairs and more sparsely with longer spinous hairs, intermixed; they are also swollen and enlarged toward the base. The import of this fact can best be conveyed to you by the statement that in all other Lepidoptera that I know of the tongue is a smooth organ and in no way armed, except near the tip. In short, the tongue in *Pronuba maculata* has become an accessory tentacle, serving and helping in pollination, but probably incapable of use for feeding purposes. These structural peculiarities justify the conclusion, which observation confirms, that Pronuba does not feed in the imago state. In other words, she has no incentive to go to the stigma with her load of pollen other than that of pollinizing, and the slight amount of nectar which the plant secretes is well calculated to lead other insects which seek it away from the stigma and thus not to interfere with Pronuba's mission.

Development and Transformations of Pronuba.

On this subject I need only remark that the action of oviposition causes a disorganization of the plant tissue in the immediate neighborhood of the apical portion of the egg and the swelling of the adjacent ovules ; that the embryo develops in the capitate end of the egg, and while the larva is white at first, or of the exact color of the young ovule, it becomes slightly greenish or roseate when full grown, which is in about a month, or coincident with the ripening of the seed. It perforates the capsule and drops to the ground, having six thoracic legs, which doubtless aid it at this period of its life. It remains through the fall, winter, and early spring months in a tough cocoon, transforms to the chrysalis state about a week before the Yuccas bloom again, and finally issues as a moth to continue the annual cycle of its career. The chrysalis (Fig. 8) has a capitate spine and a series of dorsal spines, some of which are spatulate and admirably fitted for helping it to work through the ground.

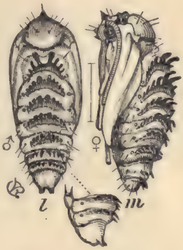

Fig. 8. — Pronuba yuccasella : *l*, male ; *m*, female chrysalis.

" The effect of the puncture of the female moth on the fruit is at once noticeable by a darker green discoloration externally. In time this becomes a depression, causing a constriction of the pod, and the irregularities of the pod (Fig. 9, *b*, *c*), which have been supposed to be characteristic of the genus Yucca, are really due to these punctures, which ordinarily occur just below the middle." The absolute need of Pronuba in the pollination of our deniscent Yuccas I have proved over and over again, in many ways. The plant never produces seed where Pronuba does not exist; it never produces seed when she is excluded artificially, and experiments which I have made with artificial or brush pollination all show that it is much more difficult to ensure complete fructification than would at first appear, and that the act of pollination is rarely performed with a brush or by using the flower's own filaments, as successfully as it is done by Pronuba. It is *Pronuba yuccasella* which pollinizes all our Yuccas east of the Rocky Mountains, so far as known, and the species is remarkably uniform in character, its appearance in time being coëtaneous with the flowering of *Yucca filamentosa.* On the western plains its appearance has become adapted to the flowering of *Yucca angustifolia*, but in the east, where these two species of Yucca are frequently grown side by side, *Y. angustifolia* flowers two or three weeks earlier than *Y. filamentosa* and generally too early to receive the visits of Pronuba, so that it produces seed only on very rare occasions. *Yucca brevifolia* is pollinized by *Pronuba synthetica* Riley, the most remarkable species of the genus, having very stout maxillary tentacles, a very stout ovipositor, shorter than that of *yuccasella*, but characterized chiefly by having fuliginous and unscaled wings and a polished, naked and flattened body—structures all well adapted for crawling between and about the compact and crowded flowers, with their

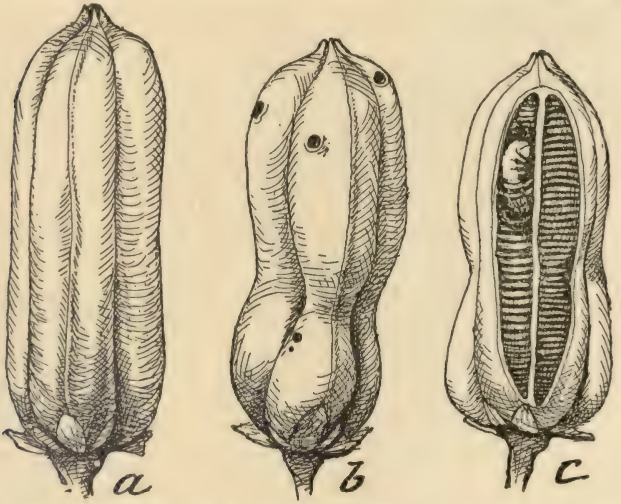

FIG. 9.—Mature pods of *Yucca angustifolia:* *a*, artificially pollinized and protected from Pronuba; *b*, normal pod, showing constrictions resulting from Pronuba puncture and exit holes of larva; *c*, one of the lobes cut open, showing larva within.

thick and leathery petals, but very abnormal in the Lepidoptera. In fact, this species strongly recalls in its general aspect some of the saw-flies belonging to the genus Dolorus, the resemblance being heightened by the rather conspicuous, cenchri-like spots, and by the conspicuous division between thorax and abdomen. It also strikingly recalls some of the Neuroptera, as *Sialis infumata.*

Now these resemblances to insects of different Orders and to families which are generally conceded to be of low type within their Order, cannot possibly be mimetic, as there can be no conceivable cause, purpose, or advantage in the mimicry. It is also impossible to account for these resemblances upon any present genetic connection. Yet we are hardly justified in disposing of them as merely accidental and without meaning. They suggest a possible synthesism in the past, when types were less specialized and present Orders had not become so well differentiated.

Yucca whipplei, which occurs in southern California, has flowers distinguished by their relatively long and stout stamens, the pollen of which is copious and glutinous, not to say mucilaginous, and a short, contracted style, with the stigma, however, expanded and covered with sticky threads. It is pollinized by *Pronuba maculata* Riley, which, as already shown, has a tongue modified into an accessory pollen-gathering organ. If any species of Yucca would seem not to need a special insect for pollination, *Yucca whipplei* is that species; for the long stamens, the sticky and abundant pollen, and the peltate, hairy stigma would all seem to facilitate ordinary pollination. Nevertheless, the very restricted style would seem to be purposely developed to counteract these other facilities, and we find a Pronuba associated with it, with a remarkably modified tongue, and with the maxillary tentacles very long and attenuated at the tip—structures which doubtless enable the moth to perform the act of pollination. I have never been able to observe the act, nor has any one yet recorded either the acts of pollination or oviposition. There will be nothing peculiar about the latter, but I shall be very glad to get actual experience in reference to the former, as I am satisfied that the observed facts will show, still more fully than in the case of *Pronuba yuccasella*, that the special modifications of both flower and insect have gone on until the mutual interdependence has become absolute.

There is much yet to learn of the pollination of other species of Yucca, and I am particularly anxious to obtain the insects which will doubtless be found associated with them. The regal tree Yucca, *Yucca filifera*, of northeastern Mexico, reaching a height of fifty feet, with its pendulous panicles five or six feet long, has a very elongate pistil and comparatively short stamens. The few pods which I have been able to examine indicate the presence of a Pronuba and doubtless of a distinct species which will prove very interesting. *Yucca baccata*, *Y. treculianea*, and all the species which are sufficiently distinctive in characters and in range, may be expected to have special Pronubas associated with them.

THE BOGUS YUCCA MOTH.

An interesting fact connected with Pronuba and Yucca pollination is that there is always associated with *Pronuba yuccasella* another moth, which bears such a remarkable superficial resemblance to it, though possessing no power of pollination, that it has caused much confusion in the past on the part of careless observers and led to a good deal of misstatement and error. This is what I have called the Bogus Yucca Moth, *Prodoxus decipiens* (Fig. 10). In size it is somewhat smaller, on the average, than Pronuba, and, while found associated with it, appears rather earlier. The female has no maxillary tentacle, but otherwise the genus has all the characteristics which would place it in the same family as Pronuba. The ovipositor is a stronger instrument (Fig. 11), but structurally homologous. The eggs are thrust into the stem while yet tender; they are elongate in form, but short and rounded at both ends, resembling the undeveloped ova in the ovaries of Pronuba. The larva is absolutely apodous (Fig. 12, *a*), forms its cocoons within the stem, and transforms the ensuensuing year to a chrysalis, which has a much stronger capitate

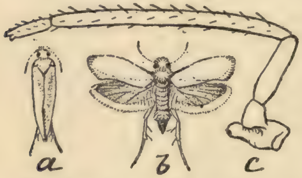

FIG. 10.—PRODOXUS DECIPIENS: *a*, imago, wings closed; *b*, female imago, wings expanded—natural size; *c*, enlarged maxillary palpus with its basal tubercle.

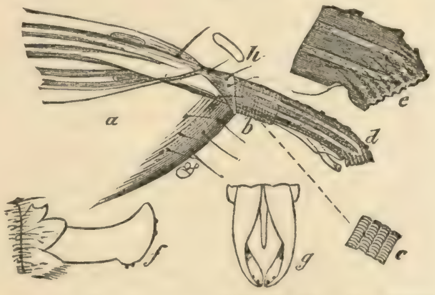

FIG 11.—GENITAL CHARACTERS OF PRODOXUS DECIPIENS: *a*, tip of ♀ abdomen rendered somewhat transparent; *b*, basal joint of ovipositor; *c*, its sculpture; *d*, terminal joint of same, its tip more enlarged; *f*, genitalia of ♂ from side; *g*, do from above; *h*, egg.

spine, but the barest trace of dorsal spines on the abdominal joints. It issues partly from the stem in giving out the moth. As I have elsewhere remarked:

"Who, studying these two species in all their characters and bearing, can fail to conclude that, notwithstanding the essential differences that distinguish them not only specifically, but generically, they are derived from one and the same ancestral form? Pronuba, depending for its existence upon the pollination of the flower, is profoundly modified in the female sex in adaptation to the peculiar function of pollination. Prodoxus, dwelling in the flesh of the fruit or in the flower-stem and only indirectly depending upon the fructification of the plant, is not so modified, but has the ordinary characters of the family in both sexes. In the former the larva quits the capsules and burrows in the ground; it has legs to aid in its work, while the chrysalis is likewise beautifully modified to adapt it to prying through the ground and mounting to the surface. The latter, on the contrary—never quitting the stem—has no legs in the larva state, and in the chrysalis state is more particularly adapted, by the

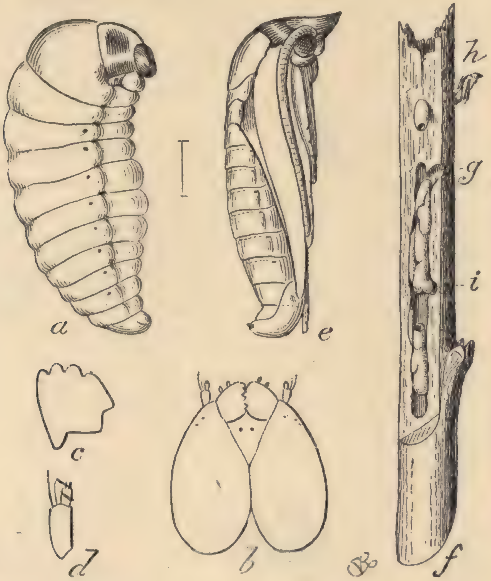

Fig. 12.—Prodoxus decipiens: *a*, larva; *b*, head from above; *c*, *d*, left jaw and antenna; *e*, pupa; *f*, infested stem cut open to show the burrows, castings, cocoons, and pupa shell (*h*)—all enlarged but *f*, the hair-line between *a* and *c* showing natural length.

prominence of the capital projection, to piercing the slight covering of the stem left ungnawed by the larva. The former is very regular in its appearance as a moth at the time of the flowering of the Yuccas in their native range. The latter appears earlier, as the food of its larva is earlier ready, and the female could not oviposit in the riper stem."

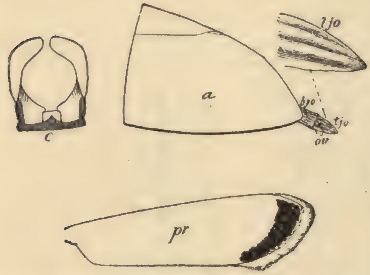

FIG. 13.—PRODOXUS MARGINATUS: *a*, anal abdominal joint of female — × 26; *b j o*, basal joint of ovipositor; *t j o*, terminal joint do.; *ov*, oviduct; *c*, claspers of male from above — × 18; *pr*, front wing—hair-line showing natural size.

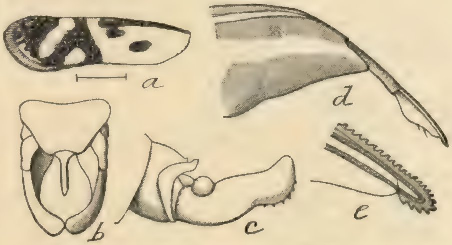

FIG. 14.—PRODOXUS Y-INVERSUS: *a*, left front wing, hair-line underneath showing natural size; *b*, genitalia of male, dorsal view — × 14; *c*, do., lateral view — × 18; *d*, anal joint of female with ovipositor exserted, lateral view — × 20; *e*, tip of ovipositor still further enlarged.

Some ten species of this genus Prodoxus have been described, all of them having the very same structural characteristics and in the adolescent states being scarcely distinguishable. *Prodoxus decipiens* is associated with *Pronuba yuccasella* east of the Rocky Mountains, and *Prodoxus sordidus* is similarly associated with *Pronuba synthetica*, breeding in the flower stems of *Yucca brevifolia*. All the other species are associated with *Pronuba maculata*, breeding either in the base of the capsules or in the flower stem or the main stem of *Yucca whipplei*. I have found Prodoxus larvæ in the stems of all other Yuccas which I have been able to examine, and doubtless a number of other species are yet to be discovered and characterized. The species so far known are interesting in that they illustrate in a remarkable manner what I have called fortuitous variation, or superficial colorational characters; also a great tendency to graduate into each other by variations among themselves, not only in the structure of the ovipositor and the male genitalia but in the wing markings. The time to which these remarks are limited will prevent my going into descriptive details, and

I content myself with illustrating in this connection a few of the more distinctly marked species, Figs. 13, 14, 15, and 16. The genus interests us most, however, in indicating how Pronuba with all her abnormal, peculiarities, has been evolved; for though we have striking differences in habit and mode of development, of larva, pupa, and imago, between Pronuba and Prodoxus, yet the affinities are equally striking, and the two genera exemplify in an exceptional degree the power of natural selection to intensify habits and structures in opposing directions according to the requirements of the species. Prodoxus is practically dependent upon Pronuba, for if the latter did not fructify the plant, the former would have in time no flower stems to breed in, and while Prodoxus has gone on, generation after generation with comparatively little change, Pronuba has become profoundly specialized to fit it for a more specific purpose.

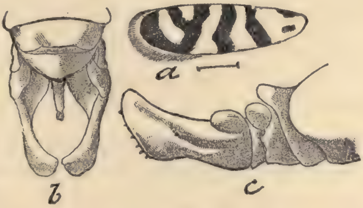

FIG. 15.—PRODOXUS COLORADENSIS: *a*, left front wing, hair-line underneath showing natural size; *b*, male genitalia, dorsal view — × 15; *c*, do., lateral view — × 18.

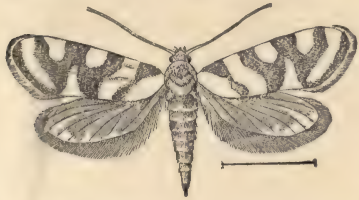

FIG. 16.—PRODOXUS RETICULATUS: Female with wings expanded—hair-line showing natural size.

CAPRIFICATION OF THE FIG.

It was my intention here to explain to you some interesting facts as to the caprification of the fig and the remarkable structural peculiarities and influence of the caprifig insects. It is, however, a somewhat complicated subject, and I could not within the time allotted me do justice both to it and the matter of Yucca pollination. As an indication, however, of how profoundly modified in this particular case the plant and the insect have become in their mutual adaptation, I may state that the perfect Smyrna fig, the most esteemed of the edible species, can be produced only by the intervention of the *Blastophaga psenes*, and that Dr. D. D. Cunningham has recently shown, in the Annals of the Royal Botanical Gardens of Calcutta, vol. I, Appendix L, 1889, by repeated examinations of the fruit of *Ficus roxburghii*, that pollination, in the ordinary meaning of that term, is, in that particular case, out of the question, and that the development of the seed in this species is exclusively due to the stimulation of the tissues caused by the puncturing of the Blastophagas; in other words, that these insects actually represent the male element in the fertilization. This is certainly the most extraordinary phenomenon in the history of fertilization, and if confirmed—and Dr. Cunningham has been most careful and circumspect in his work—it will give a more striking instance than any we have hitherto obtained of the mutual interdependence which plants and insects may attain and the surprising manner in which they may modify each other.

GENERALIZATION.

The peculiarities which I have endeavored to present to you are full of suggestion, particularly for those who are in the habit of looking beyond the mere facts of observation in endeavors to find some rational explanation of them; who, in other words, see in everything they observe significances and harmonies not generally understood. The facts indicate clearly, it seems to me, how the peculiar structures of the female Pronuba have been evolved by gradual adaptation to the particular functions which we now find her performing. With the growing adaptation to Pronuba's help, the Yucca flower has lost, to a great extent, the activity of its septal glands; yet coincident with it we find an increase in the secreting power of the stigma. This increase of the stigmatic fluid has undoubtedly had much to do with originally attracting the moth thereto, while the pollinizing instinct doubtless became more and more fixed in proportion as the insect lost the power or desire of feeding. With the mind's eye I can look back into the past and picture the gradual steps by which the Prodoxids to which I have alluded have differentiated along lines which have resulted in their present characteristics. On the one side I see variations which have become sufficiently fixed to be considered specific; yet which can have no especial bearing on the life necessities of the species, but are a consequence rather of that universal tendency to variation with which every student of Nature becomes profoundly impressed. Thus the wing-markings vary from a darker general coloring, as in *Prodoxus æenescens*, to a more uniform intermixture of the black scales among the white, as in *cinereus*, or a sparser intermixture thereof, as in *pulverulentus*. The disposition of the black scales is in spots or bands, whether transverse or longitudinal, as in *marginatus*, *reticulatus*, *Y-inversus*, etc. These are fortuitous variations, for I cannot believe that the disposition of these marks where, as in these cases, they take every form that is conceivable, can be of any benefit to the species, any more than the mere variation in the number of lobes in the leaves of different oaks growing under like conditions can be of any particular benefit to the species, however useful to us in classification.

In my address before the Section of Biology of the American Association for the Advancement of Science, at Cleveland, in 1888, I have discussed the various forms and causes of variation, and especially the limitations of natural selection, stating expressly that this last "deals only with variations useful to the organism in its struggle for existence, and can exert no power in fixing the endless number of what, from present knowledge, we are obliged to consider fortuitous characters," and I have long recognized, from my studies of insect life, the existence of these fortuitous variations. The subject has since been very well elaborated by Professor Ward in his communication to the Society (December 15, 1888) on "Fortuitous variation as illustrated by the genus Eupatorium" and in his Annual Address (January 24, 1891) on "Neo-Darwinism and Neo-Lamarckism," and the Prodoxidæ furnish an excellent illustration of this fortuitous variation. Yet at the same time that we note this chance variation, as exemplified in a number of the species of Prodoxus, which are mere ravagers or despoilers and have not been brought into any special or mutual relations with the plant, we have, on the other hand, in *Pronuba yuccasella*, correlated with the other striking structural modifications which have brought it into such special relations with the plant, an elimination of all maculation or markings upon the primaries, and a purely white coloring so fixed that it shows absolutely no variation over half the continent. The structural variation has been necessary—a consequence of effort, environment, and natural selection. The color variation, on the contrary, has not been absolutely necessary, yet has nevertheless gone on in lines which, tending to give greater protective resemblance to the flower, have in the long run proved to be, perhaps, the most advantageous. I thus recognize three distinct lines of variation as exemplified in these Prodoxidæ, and what is true of them is, I believe, true of all alliances of organisms. The first and most important is structural and generic; it is absolutely essential and is preserved in its perfection by the elimination, through natural selection, of all forms departing from it. The second is merely coincident, not essential, but nevertheless along lines that are of secondary advantage. The third is purely fortuitous, affects superficial features in the main, is unessential (a consequence of the inherent tendency of all things to vary), and takes place along all lines and in all directions where there is no counteracting resistance.

Now, when it comes to the bearing which the history of these little moths has upon some of the larger questions that are now concerning naturalists (for instance, the transmission of acquired characters, or the origin, development, and nature of the intelligence displayed by the lower animals), broad fields of interesting opinion and conclusion open up before us—fields that cannot possibly be explored without trenching too much upon your time. I will close, therefore, with a few summary expressions of individual opinion, without attempting to elaborate the reasons in detail, and with the object of eliciting further discussion, which is one of the objects of the paper. My first conviction is that insect life and development give no countenance to the Weissmann school, which denies the transmission of functionally acquired characters, but that, on the contrary, they furnish the strongest refutation of the views urged by Weissman and his followers. The little moths of which I have been speaking, and indeed the great majority of insects—all, in fact, except the truly social species—perform their humble parts in the economy of nature without teaching or example, for they are, for the most part, born orphans, and without relatives having experience to communicate. The progeny of each year begins its independent cycle anew. Yet every individual performs more or less perfectly its allotted part, as did its ancestors for generation after generation. The correct view of the matter, and one which completely refutes the more common idea of the fixity of instinct, is that a certain number of individuals are, in point of fact, constantly departing from the lines of action and variation most useful to the species, and that these are the individuals which fail to perpetuate their kind and become eliminated through the general law of natural selection.

Whether these actions be purely unconscious and automatic or more or less intelligent and conscious does not alter the fact that they are necessarily inherited. The habits and qualities that have been acquired by the individuals of each generation could have become fixed in no other way than through heredity. Many of these acts, which older naturalists explained by that evasive word "instinctive," may be the mere unconscious outcome of organization, comparable to vegetative growth; but insects exhibit all degrees of intelligence in their habits and actions, and they perform acts which, however voluntary and, as I believe, conscious in many cases, as in that of our Yucca Moth, could not be performed were the tendency not inherited. Every larva which spins or constructs a hibernaculum, or a cocoon in which to undergo its transformations, exemplifies the potent power of heredity in transmitting acquired peculiarities. A hundred species of parasitic larvæ, *e. g.*, of the family Braconidæ, which in themselves are almost or quite indistinguishable from one another structurally, will nevertheless construct a hundred distinctive cocoons—differing in form, in texture, in color, and in marking—each characteristic of its own species and in many instances showing remarkable architectural peculiarities. These are purely mechanical structures, and can have little or nothing to do with the mere organization or form or structure of the larva, but they illustrate in the most convincing manner the fact that the tendency to construct and the power to construct the cocoon after some definite plan must be fixed by heredity, since there is no other way of accounting for it. This fact alone, which no one seems to have thought of in the discussion, should be sufficient to confound the advocates of the non-transmissibility of acquired characteristics.

Thus to my view modification has gone on in the past, as it is going on at the present time, primarily through heredity in the insect world. I recognize the physical influence of environment; I recognize the effect of the interrelation of organisms; I recognize, even to a degree that few others do, the psychic influence, especially in higher organisms—the power of mind, will, effort, or the action of the individual as contradistinguished from the action of the environment; I recognize the influence of natural selection, properly limited; but above all, as making effective and as fixing and accumulating the various modifications due to these or whatever other influences, I recognize the power of heredity, without which only the first of the influences mentioned can be permanently operative.

Let us stop for a moment to ponder what the intricate adjustments between plants and animals, and especially between plants and insects, mean, when these have become so profoundly modified by each other that their present existence actually depends the one on the other. As palæontology shows, and as Professor Ward has more particularly so well explained, there was for ages no vegetation but the flowerless plants. The first were the low cellular cryptogams, consisting chiefly of marine algæ, and these, the lowest and first organisms upon the planet, have endured through all geologic time and obtain to-day. Next, beginning in the upper Silurian and reaching their maximum in the Carboniferous, came the vascular cryptogams, of which the ferns constituted the bulk. Arborescent and gigantic compared with present forms, they mingled with the now extinct Lycopodineæ to form the bulk of the forests of the coal period. Then came the Phænogams, or flowering plants, and in this great division the Cycadaceæ and coniferæ (pines, firs, etc.) were the chief forms during Mesozoic times. So far the seed has been exposed. Now come the Angiosperms, in which the seed is protected in the ovary or pericarp, and the Monocotyledons (palms, sedges, etc.) precede the Dicotyledons, while of these last the Apetalæ, Polypetalæ, and Gamopetalæ succeed each other in the order of their naming.

In brief, to use his own words, the development has been from the simple to the complex; from the flowerless to the flowering; from the endogenous to the exogenous; from the apetalous to the gamopetalous; and this succession corresponds to the best systems of classification of existing forms.

Both Cryptogams and Phænogams began existence during the Silurian, and there has been a race for supremacy ever since, with our present flora as the result. It is also a fact of the greatest significance that the same palæontological evidence which gives us this record also tells us that there has been a corresponding development of insect life, from the lower Neuroptera and Orthoptera, which prevailed in the days when Anemophilous plants reigned, to the higher Lepidoptera and Hymenoptera, which appeared only as the higher flowering plants developed in the Jurassic and Cretaceous.

I do not hesitate, in this connection, to refer to another of Professor Ward's conclusions set forth in one of his interesting articles, namely, that most of the higher flowering plants would speedily perish were insect aid withdrawn, and that but for such aid in the past we should now be without most of our gorgeous flora, and that insects have actually paved the way for man's existence by the part they have played in the development of fruit and nut bearing plants.

VOL. VII, PP. 105-132 JUNE, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THIRD LIST OF ADDITIONS TO THE FLORA OF WASHINGTON, D. C.

BY THEODOR HOLM.*

The following list is supplemental to Professor Lester F. Ward's "Guide to the Flora of Washington and Vicinity,"† since the publication of which two additional lists have been issued.‡ The present paper covers the period from April 1, 1886, to April 1, 1892. The species which are new to the flora have been marked with an asterisk, but besides these many of the rarer species have been included, with records of new localities. The known flora has been increased by about 80 species and varieties since the year 1886. Some of the plants that are new to the District seem to have been accidentally introduced; for example: *Silene noctiflora*, *Althæa cannabina*, *Sida Napæa*, *Medicago maculata*, *Lespedeza striata*, *Veronica agrestis* and *V. hederæfolia*, *Brunella laciniata*, *Panicum miliaceum*, *Hordeum pratense*, etc. The others, however, are species indigenous to the United States which heretofore have been overlooked or which may have immigrated from adjacent territory. In the latter category appear to be several species from the Potomac shore: *Ranunculus Pennsylvanicus*, *Flœrkea proserpinacoides*, *Phacelia Covillei*, etc. The flora of the District is, however, probably not yet thoroughly known, and we need simply to recall the fact that a locality so rich as that near Silver Hill thus far seems to have escaped attention, and the river banks between Chain Bridge and Great Falls are yet far from being well explored.

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* Presented at a meeting of the Biological Society of Washington, May 14, 1892.

† Bulletin No. 22, U. S. National Museum, 1881.

‡ Ward, Proc. Biol. Soc., vol. II, 1885, pp. 84–87; Knowlton, *ibid.*, vol. III, 1886, pp. 106–132.

It was the author's intention to give some additional notes in regard to the time of flowering, as many new facts have been reported; but these have not been included in the following list, because it has been found almost impossible to state with any certainty the true dates for many of the species in question. This is especially true of the spring flowers. In the year 1890, for instance, about forty species were found in bloom as early as the 15th of January, but in 1892 only a few were observed before the end of March.

It has been thought best to follow the nomenclature and arrangement of Professor Ward's Flora.

It is intended to continue the publication of lists of additions, and the botanists of Washington are requested to send to the author their notes upon species new to the District and upon new localities for rare plants.

RANUNCULACEÆ.

3. Clematis Virginiana L.

Anacostia road and Mill road, flowering in the first week of August. H. W. Henshaw.

***20*a*. Ranunculus Pennsylvanicus** L.

On the Virginia shore of the Potomac, just above Aqueduct Bridge; collected with flowers and fruit in the third week of August. The author.

***22*a*. Caltha palustris** L.

Flowering specimens brought to Center Market were said to have been collected in Anacostia River marsh at Bennings Bridge and three miles north of Bladensburg. The specimens referred to in Mr. Knowlton's list as collected in Rock Creek belong not to this species, but to *Ranunculus Ficaria* L. It is very doubtful, however, whether these specimens were really found in the District.

26. **Aconitum uncinatum** L.

Woodley Park, first week of September. H. W. Henshaw.

BERBERIDACEÆ.

32. **Berberis vulgaris** L.

A tall shrub on the top of a hill between Eckington and Brookland. The author.

33. **Caulophyllum thalictroides** Michx.

Woodley Park. J. G. Gurley.

NYMPHÆACEÆ.

*38*a*. **Nymphæa tuberosa** Paine.

Below the Alexandria turnpike bridge, Little Hunting Creek, Va. William Hunter.

SARRACENIACEÆ.

39. **Sarracenia purpurea** L.

Silver Hill. G. W. Oliver.

PAPAVERACEÆ.

40. **Papaver dubium** L.

On the canal embankment just above Outlet Lock. J. G. Gurley. Gravelly flat at the mouth of Cystopteris Run, below Chain Bridge. E. S. Burgess.

40*a*. **Argemone Mexicana** L.

Seventeenth street near Boundary. W. H. Seaman. Abundant in Brookland. The author.

CRUCIFERÆ.

47. **Nasturtium silvestre** R. Br.

Open lot east of the Navy Yard. Lester F. Ward. River margin at the stone quarry below Rhododendron Run. E. S. Burgess.

*49*a*. **Nasturtium palustre** DC. var. **hispidum** Fisch. & Mey.

Flats of the Potomac below Chain Bridge. G. B. Sudworth.

*50*a*. **Nasturtium sessiliflorum** Nutt.

Flats below Chain Bridge, May 29, 1890. G. B. Sudworth.

55. Arabis dentata Torr. & Gray.

Common on the Potomac shore just above Aqueduct Bridge, Virginia. The author.

70. Sisymbrium Alliaria Scop.

High Island. Miss Bebb.

72. Camelina sativa Crantz.

Several specimens were observed along the Chesapeake and Ohio Canal, east of High Island, in the third week of May. G. B. Sudworth.

74. Brassica nigra Koch.

Upon the rocks on the Virginia shore at Chain Bridge. The author.

78. Thlaspi arvense L.

Below the Insane Asylum. Lester F. Ward.

CISTACEÆ.

80. Helianthemum Canadense Michx.

Mount Hamilton. E. S. Burgess. Opposite Oak Hill Cemetery and at Bennings. G. W. Oliver.

VIOLACEÆ.

*89*b*. **Viola canina** L., var. **Muhlenbergii** Gray.

Fourteenth street road and Rock Creek, June, 1889. G. W Oliver.

*89*c*. **Viola odorata** L.

Near Accotink, Fairfax County, Virginia. William Hunter.

POLYGALACEÆ.

96. Polygala incarnata L.

Terra Cotta swamp and along the Queens Chapel road. Lester F. Ward and the author.

98. **Polygala fastigiata** Nutt.

Saul's nursery, Bladensburg turnpike. Lester F. Ward and the author.

99*a*. **Polygala Curtissii** Gray, var. **pycnostachya** Gray.

Abundant at Fort Myer. The author.

100. **Polygala ambigua** Nutt.

Common near Fort Ethan Allen. H. W. Henshaw. Linden Farm, Seventh and Eighth street roads, and Kalorama. E. S. Burgess. Brookland. The author. Fort Myer. H. W. Henshaw.

*100*a*. **Polygala cruciata** L.

Very abundant in a sphagnum swamp near Silver Hill. G. W. Oliver.

*101*a*. **Polygala verticillata** L.

Abundant near Fort Myer, flowering in the third week of August. H. W. Henshaw.

CARYOPHYLLACEÆ.

106. **Silene nivea** Otth.

Alexander Island, flowering in the last week of June. H. W. Henshaw. Gulf Landing, Potomac shore. G. B. Sudworth.

*107*a*. **Silene noctiflora** L.

Columbia road, August. W. H. Seaman.

*110*a*. **Lychnis vespertina** Sibth.

Numerous flowering specimens found in a meadow near Bunker Hill; first week of May, 1892. The author.

*117*a*. **Stellaria graminea** L.

Abundant in the hedge of Chinese arbor-vitæ north of the conservatories, Department of Agriculture. George Vasey.

ILLECEBRACEÆ.

124*a*. **Scleranthus annuus** L.

West bank of Rock Creek, Georgetown. G. W. Oliver.

PORTULACACEÆ.

126, **Claytonia Virginica** L.

A double-flowered form observed at Beaver Dam Branch. Lester F. Ward.

*126*a*. **Talinum teretifolium** Pursh.

Dry moorland beyond Silver Hill. G. W. Oliver.

ELATINACEÆ.

*126*b*. **Elatine Americana** Arn.

Near Chain Bridge, on the Virginia shore of the Potomac, March, 1891. The author.

HYPERICACEÆ.

128. **Ascyrum stans** Michx.

Very common in several swamps near Silver Hill. G. W. Oliver. Accotink, Fairfax County, Virginia. William Hunter. Swamp back of Hyattsville. Lester F. Ward.

MALVACEÆ.

*137*a*. **Althæa cannabina** L.

Vacant lots south of the Capitol; escaped from cultivation. G. W. Oliver.

*138*a*. **Sida Napæa** Cav.

Potomac flats near the continuation of Eighteenth street; in flower during the first week of October. E. S. Burgess.

GERANIACEÆ.

*151*a*. **Flœrkea proserpinacoides** Willd.

High Island. M. B. Waite.

ILICINEÆ.

*158*a*. **Ilex glabra** Gray.

Swamp beyond Silver Hill. G. W. Oliver.

SAPINDACEÆ.

174. Acer saccharinum Wang.

A sapling of this, together with one of var. *nigrum*, neither in flower, was found on the second island in the Potomac above Feeder Dam Island. F. V. Coville.

LEGUMINOSÆ.

186. Baptisia australis R. Br.

Great Falls. H. W. Henshaw.

* **191***a*. **Medicago maculata** Willd.

Fifteenth street, opposite the Panorama building. Miss A. M. Hayes. White House grounds. Countess Sponneck.

* **194***a*. **Trifolium medium** L.

A single specimen found in an old sandy field between Georgetown and Alexandria. G. B. Sudworth.

195*a*. **Trifolium hybridum** L.

Monument grounds. Miss A. M. Hayes. Brookland, Soldiers Home, and near Fort Myer. The author.

* **195***b*. **Trifolium incarnatum** L.

Several specimens collected in the city parks. C. S. Prosser.

* **220***a*. **Lespedeza striata** L.

Railroad banks at the south end of Long Bridge; also along the Conduit road near the distributing reservoir. G. W. Oliver. Corcoran Woods. Lester F. Ward.

230. Clitoria Mariana L.

Abundant, with ripe fruits, Terra Cotta and Rock Creek. Lester F. Ward and the author.

ROSACEÆ.

* **257***a*. **Rubus odoratus** L.

Several flowering specimens found in a damp, wooded ravine near the National Observatory, in the second week of June, 1890. G. B. Sudworth.

270. Poterium Canadense Benth. & Hook.

Swamp near Bladensburg. H. W. Henshaw. Holmead Swamp. Lester F. Ward and the author.

282. Cratægus Oxyacantha L.

Corcoran Woods; a single shrub. The author.

285. Cratægus parvifolia Ait.

Beyond Silver Hill. G. W. Oliver.

SAXIFRAGACEÆ.

289. Mitella diphylla L.

South bank of Cascade Run, near the mouth. E. S. Burgess.

291. Chrysosplenium Americanum Schwein.

Rock Creek, nearly opposite Crystal Spring. Lester F. Ward. Several places in the ravines above Aqueduct Bridge, on the Virginia shore. The author.

DROSERACEÆ.

300. Drosera rotundifolia L.

Sarracenia Swamp and near Fort Ethan Allen. H. W. Henshaw. Common in swamps east of Silver Hill. G. W. Oliver.

MELASTOMACEÆ.

***306*a*. Rhexia Mariana** L.

Near Accotink, Fairfax County, Virginia. William Hunter. Clearing in the pine woods, Marlborough road. G. W. Oliver.

LYTHRACEÆ.

307. Ammania humilis Michx.

Swamp in Piney Branch woods, and very common in swamps between Eckington and Brookland. The author.

ONAGRACEÆ.

***316*a*. Œnothera pumila** L.

Brentwood road, opposite Eckington. Lester F. Ward. Dry hills near Fort Myer; flowering in the second week of May. The author.

UMBELLIFERÆ.

342. **Thaspium aureum** Nutt.

Great Falls and above Aqueduct Bridge. The author.

ARALIACEÆ.

349. **Aralia spinosa** L.

Numerous small trees, but not flowering, near the Fort Myer road. Lester F. Ward.

350. **Aralia nudicaulis** L.

Rocks above the Promontory, Rock Creek. Lester F. Ward Rocks above Aqueduct Bridge, on the Potomac shore. Fr. Svendsen and the author.

352. **Aralia trifolia** Decsne.

Piney Branch below Fourteenth street bridge; with flowers in the third week of April. Countess Sponneck.

CAPRIFOLIACEÆ.

360. **Viburnum nudum** L.

Sphagnum swamp, Hensons Creek. G. W. Oliver.

*369*a*. **Diervilla trifida** Moench.

Rock Creek. G. W. Oliver.

RUBIACEÆ.

372. **Houstonia purpurea** L., var. **longifolia** Gray.

Very common on the flats below Chain Bridge; also on rocks at Great Falls. The author.

374. **Mitchella repens** L.

The variety with white fruits has been collected by G. W. Oliver.

377. **Galium asprellum** Michx.

In woods near the Insane Asylum. Lester F. Ward and the author.

VALERIANACEÆ.

383a*. **Valerianella Woodsiana** Walp.

High Island and the Canal bank below, May. F. V. Coville.

384. Fedia olitoria Vahl.

Massachusetts avenue extended. E. S. Burgess.

COMPOSITÆ.

388a*. **Vernonia Noveboracensis** Willd., var. **latifolia** Gray.

Terra Cotta, Linnæan Hill, and Cascade Run. E. S. Burgess.

398a*. **Eupatorium perfoliatum** L., var. **truncatum** Gray.

Woodley Park. E. S. Burgess.

400a*. **Eupatorium aromaticum** L., var. **melissoides** Gray.

Woodley Park; in flower during the third week of September. E. S. Burgess.

402. Mikania scandens L.

Terra Cotta swamp. H. W. Henshaw and E. S. Burgess. Swamp near Queens Chapel road. Lester F. Ward and the author.

404. Liatris scariosa Willd.

A single specimen found above Chain Bridge, on the Virginia shore; flowering in the second week of October. E. S. Burgess.

415. Solidago rigida L.

Still persisting at Woodley Bridge, October, 1888. E. S. Burgess.

415a*. **Solidago serotina** Ait.

Abundant near the second lock and near the Anacostia road beyond Sligo. H. W. Henshaw.

423a*. **Solidago Canadensis** L., var. **scabra** Torr. & Gray.

Rock Creek; flowering in October. E. S. Burgess.

423b*. **Solidago Canadensis** L., var. **procera** Torr. & Gray.

Near Spout Run. E. S. Burgess.

*428*a*. **Aster Shortii** Hook.

A mile above Aqueduct Bridge, on the shore of the Potomac, near Spout Run; in flower in the last week of October. E. S. Burgess.

*428*b*. **Aster azureus** Lindl.

Terra Cotta; flowering in the second week of October. E. S. Burgess.

430. Aster concolor L.

Terra Cotta swamp; in flower during the second week of October. E. S. Burgess. Rather common near the Reform School. Lester F. Ward and the author.

*431*a*. **Aster patens** Ait., var. **phlogifolius** Nees.

Woodley Park; in flower during the first week of October. E. S. Burgess.

432. Aster lævis L.

Still persisting in Woodley Park, October, 1888. E. S. Burgess.

435. Aster cordifolius L.

Just beginning to bloom in the last week of August. H. W. Henshaw.

*444*a*. **Aster puniceus** L., var. **lucidulus** (Wend.) Gray.

Terra Cotta. H. W. Henshaw.

446. Aster prenanthoides Muhl.

River bank near the storage-house of the Independent Ice Company. E. S. Burgess.

447. Aster oblongifolius Nutt.

Above Hydrophyllum Run. E. S. Burgess.

448. Aster Novæ-Angliæ L.

Woodley Park. J. J. Shirley. Potomac flats. Lester F. Ward and the author. Eighteenth street extended. Mouth of Foundry Run. Outlet Lock. E. S. Burgess.

450. **Aster umbellatus** Mill.

Terra Cotta swamp, near the railway track. Swamps below Freedman's Village. E. S. Burgess.

453. **Erigeron bellidifolius** Muhl.

Woodley Park. Lester F. Ward. Fort Totten. The author.

457. **Baccharis halimifolia** L.

Near Accotink Station, Virginia, on the Alexandria and Fairfax railway; flowering in the second week of September. William Hunter. Opposite Marshall Hall. G. W. Oliver.

*459*a*. **Antennaria plantaginifolia** Hook., var. **monocephala** Gray.

Pierce's Mill Bridge, April 28, 1889. G. W. Oliver.

462. **Gnaphalium purpureum** L.

Potomac shore. Lester F. Ward. Common in Terra Cotta Swamp. Brookland. The author.

465. **Silphium trifoliatum** L.

Still persisting near Woodley Bridge, October, 1888. E. S. Burgess.

*465*a*. **Silphium laciniatum** L.

At the southeastern end of Woodley Bridge; first discovered by J. W. Chickering; found more recently by E. S. Burgess.

*472*a*. **Heliopsis scabra** Dun.

Near Spout Run; flowering in the first week of October. E. S. Burgess.

473. **Eclipta alba** Hassk.

Piney Branch, above the bridge at Fourteenth street. E. S. Burgess.

494*a*. **Bidens connata** Muhl.

Accotink, Fairfax County, Virginia. William Hunter.

497*a*. **Galinsoga parviflora** Cav.

Corner of Rhode Island avenue and S street. Piney Branch, above the bridge at Fourteenth street. E. S. Burgess. Massachusetts avenue, between Fourteenth and Fifteenth streets. The author.

* **502*d*. Artemisia caudata** Michx.

Near Alexandria; introduced. G. W. Oliver.

503. Arnica nudicaulis Ell.

Reform School. E. S. Burgess. Terra Cotta. Rock Creek. Queen's Chapel road. Bowen road. H. W. Henshaw.

* **513*a*. Cnicus pumilus** Torr.

Woodley Park. G. B. Sudworth.

* **524*a*. Hieracium Marianum** Willd.

Bank of the Potomac, opposite the south end of Analostan Island. E. S. Burgess.

* **529*a*. Lactuca Scariola** L.

This plant has lately been observed in several places within the city by Lester F. Ward, F. V. Coville, and the author.

LOBELIACEÆ.

537. Lobelia cardinalis L.

Holmead Swamp. Along the road between Cabin John Bridge and Great Falls. Near Corcoran Woods. Lester F. Ward and the author.

539. Lobelia puberula Michx.

Terra Cotta. The author.

CAMPANULACEÆ.

543. Campanula Americana L.

Cabin John Run. Miss Joyce Lee.

ERICACEÆ.

550. Epigæa repens L.

Autumnal flowers found in the last week of October. F. W. Clarke.

551. Gaultheria procumbens L.

Near Marlborough road. One mile above Blagden's Mill. G. W. Oliver.

558. Rhododendron viscosum Torr., var. **glaucum** Gray.

Swamp northwest of Terra Cotta. E. S. Burgess.

559. Rhododendron vizcosum Torr., var. **nitidum** Gray.

Swamp northwest of Terra Cotta. E. S. Burgess.

PYROLACEÆ.

564. Pyrola secunda L.

Near Chain Bridge, on the Virginia shore. The author.

PRIMULACEÆ.

577. Lysimachia nummularia L.

Along a stream near Terra Cotta. I. C. Williams and the author.

***577*a*. Centunculus minimus** L.

Field opposite the white school-house at Woodlawn, along the Alexandria and Accotink turnpike; last week of June. William Hunter.

579. Samolus Valerandi L., var. **Americana** Gray.

Abundant above and below Chain Bridge. Along the Potomac below Analostan Island. G. B. Sudworth.

APOCYNACEÆ.

585. Vinca minor L.

Back of Uniontown, along a stream in a hedge of *Smilax;* thoroughly established. Lester F. Ward. Hillside in South Brookland. The author.

585*a*. Apocynum androsæmifolium L.

Between Corcoran Woods and the Baltimore and Ohio Railroad. Lester F. Ward and the author.

ASCLEPIADACEÆ.

594. Asclepias obtusifolia Michx.

Anacostia River below the bridge. Reform School. Terra Cotta. E. S. Burgess.

595. **Asclepias variegata** L.

Terra Cotta. Reform School. E. S. Burgess. Fort Myer. The author.

596. **Asclepias quadrifolia** Jacq.

Chamælirium Run. E. S. Burgess.

597. **Asclepias verticillata** L.

Cascade Run. E. S. Burgess. Rock Creek. Great Falls. Lester F. Ward and the author.

599. **Enslenia albida** Nutt.

Abundantly flowering under Chain Bridge, in the middle of July. Lester F. Ward and the author.

600. **Gonolobus obliquus** R. Br.

Bluffs of the Potomac, at two localities between M. E. Church and Chain Bridge. H. W. Henshaw and E. S. Burgess.

LOGANIACEÆ.

*601*a*. **Spigelia Marilandica** L.

In a moist thicket in the vicinity of Mount Vernon; flowering in June, 1890. G. B. Sudworth.

GENTIANACEÆ.

*602*a*. **Sabbatia gracilis** Salisb.

Low meadow east of Falls Church. C. Kinsley.

604. **Gentiana Andrewsii** Griseb.

Flats between Aqueduct and Chain bridges. Lester F. Ward and the author. Terra Cotta Swamp. Lester F. Ward.

607. **Obolaria Virginica** L.

Rock Creek. G. W. Oliver. Several places in North Brookland. The author.

POLEMONIACEÆ.

608. **Phlox paniculata** L.

Great Falls. Lester F. Ward and the author.

609. **Phlox maculata** L.

Near Chain Bridge, on the Virginia shore. Terra Cotta Swamp. The author.

613. **Polemonium reptans** L.

Munson Hill. H. W. Henshaw.

HYDROPHYLLACEÆ.

615. **Ellisia Nyctelea** L.

Poplar Point. E. S. Burgess. On the Potomac shore, Virginia side, near Aqueduct Bridge. The author.

*615*a*. **Phacelia Covillei** Wats.

Larkspur Island. Lester F. Ward, F. V. Coville, and M. B. Waite.

616. **Phacelia Purshii** Buckl.

High Island. Lester F. Ward. On the Virginia shore of the Potomac, near Aqueduct Bridge. The author.

617. **Phacelia parviflora** Pursh.

Great Falls; observed in great abundance. The author. Analostan Island and High Island. G. B. Sudworth.

CONVOLVULACEÆ.

630. **Ipomæa coccinea** L.

Vacant lot near the Baptist Church, southeast corner of Rawlin's Square. E. S. Burgess.

635. **Convolvulus spithamæus** L.

Reform School. E. S. Burgess.

*636*a*. **Convolvolus sepium** L., var. **Americanus**.

Near Aqueduct Bridge, on the Virginia shore. The author.

640*a*. **Cuscuta compacta** Juss.

Near Fort Myer. The author.

SOLANACEÆ.

*641*a*. **Solanum Dulcamara** L.

Hedgerow a short distance west of the railroad below Alexandria. G. W. Oliver.

643. **Physalis pubescens** L.

Still persisting in Lobelia Run, Woodley Park. E. S. Burgess.

*643*a*. **Physalis Philadelphica** L.

Woodley Park. G. B. Sudworth.

SCROPHULARIACEÆ.

651. **Linaria Canadensis** Dumont.

Abundant in dry fields near Terra Cotta. I. C. Williams and the author.

654. **Scrophularia nodosa** L.

Virginia shore near Spout Run. E. S. Burgess. Cascade Run. Lester F. Ward. Flats below Chain Bridge. The author.

656. **Pentstemon pubescens** Soland.

Virginia shore of the Potomac above the Dixie Landing. Mount Hamilton. E. S. Burgess. Mouth of Cystopteris Run. H. W. Henshaw.

657. **Pentstemon lævigatus** Soland.

Mouth of Cystopteris Run. H. W. Henshaw. High Island. Near Great Falls. E. S. Burgess. Corcoran Woods. Near Fort Myer. The author.

666. **Veronica Americana** Schwein.

Goldianum Run. Lester F. Ward.

669. **Veronica serpyllifolia** L.

Woodlawn, Fairfax County, Virginia. William Hunter.

*669*a*. **Veronica agrestis** L.

Accotink, Fairfax County, Virginia. William Hunter. The plant was collected in full bloom in the first week of February.

*671*a*. **Veronica hederæfolia** L.

Smithsonian grounds; in flower in the last week of April. H. M. Smith.

672. Buchnera Americana L.

East of Cabin John Bridge. H. W. Henshaw. Terra Cotta. Lester F. Ward and the author.

675. Gerardia quercifolia Pursh.

Fort Myer. H. W. Henshaw.

676. Gerardia purpurea L.

A white-flowered variety, collected near Woodlawn, Fairfax County, Virginia. William Hunter.

OROBANCHEÆ.

681. Orobanche minor L.

Mount Vernon Square, near Terra Cotta. E. S. Burgess. Piney Branch woods. The author.

682. Aphyllon uniflorum Gray.

Chamælirium Run. E. S. Burgess. Insane Asylum woods. Near Aqueduct Bridge, on the Virginia shore. The author. Bull Run River, Virginia. Rock Creek. H. W. Henshaw.

LABIATÆ.

713. Pycnanthemum muticum Pers.

Queen's Chapel road and near Fort Myer. H. W. Henshaw.

725. Lophanthus nepetoides Bth.

Fort Bennett. H. W. Henshaw.

*734*a*. **Brunella laciniata** L.

South bank of the Potomac, in a pasture a few hundred yards west of the uppermost steamboat landing above Aqueduct Bridge; flowering in the second week of July. F. V. Coville.

738*a*. **Lamium purpureum** L.

Agricultural grounds. G. B. Sudworth.

PLANTAGINEÆ.

745. Plantago Patagonica Jacq., var. **aristata** Gray.

Woodley Park. G. B. Sudworth.

POLYGONACEÆ.

773*a.* **Polygonum tenue** Michx.

Lanier Heights. E. S. Burgess.

775a.* **Polygonum Hartwrightii** Gray.

Potomac flats just below Outlet Lock; not seen in flower. F. V. Coville.

ARISTOLOCHIACEÆ.

788. Aristolochia Serpentaria L.

Seven Locks. E. S. Burgess. Observed in several places in woods, but always scattered. Lester F. Ward, G. W. Oliver, and the author.

LORANTHACEÆ.

794. Phoradendron flavescens Nutt.

Growing upon *Acer rubrum*, *Quercus tinctoria*, and *Q. coccinea.* Woodlawn, near Mount Vernon, Virginia. William Hunter. On *Acer rubrum*, five miles west of Falls Church, Virginia. Lester F. Ward.

EUPHORBIACEÆ.

800. Euphorbia commutata Eng.

Cystopteris Run. E. S. Burgess. Virginia shore of the Potomac above Aqueduct Bridge. The author.

801. Phyllanthus Carolinensis Walt.

Rediscovered in Corcoran Woods. G. W. Oliver.

URTICACEÆ.

816. Parietaria Pennsylvanica Muhl.

In a thicket between Aqueduct Bridge and Chain Bridge, near the Canal road. Lester F. Ward and the author.

JUGLANDACEÆ.

818. Carya alba Nutt.

One large tree, standing on the north side of the Braddock road near Back Lick Run, opposite the *Ophioglossum* grounds. Lester F. Ward.

MYRICACEÆ.

825. Myrica cerifera L.

Sphagnum swamp beyond Silver Hill. G. W. Oliver. North Brookland. Robert Ridgway.

CUPULIFERÆ.

831*a*. Quercus alba × obtusiloba.

Near Silver Spring. H. W. Henshaw.

831*b*. Quercus alba × Prinus.

Rockville road opposite Oakview. H. W. Henshaw.

***833*a*. Quercus lyrata** Walter.

About one hundred yards east of High Island, near the Potomac River. G. B. Sudworth.

835. Quercus Michauxii Nutt.

Above the Silver Hill road. Lester F. Ward. Owl Bridge, Northwest Branch of Paint Branch, Maryland. H. W. Henshaw.

836*a*. Quercus Prinus × alba.

Brightwood. H. W. Henshaw.

837. Quercus Muhlenbergii Engelm.

Blagden's Mill. Bluffs above the canal road west of Chain Bridge. Broad Branch. First run east of Cabin John Bridge. H. W. Henshaw.

838. Quercus prinoides Willd.

Bladensburg road. H. W. Henshaw.

***840*a*. Quercus coccinea × falcata.**

Brightwood, between Bunker Hill road and Brentwood road. H. W. Henshaw.

***842*a*. Quercus falcata × tinctoria.**

Le Droit Park. H. W. Henshaw.

848. Quercus Leana Nutt.

Cabin John Bridge. H. W. Henshaw.

849. Quercus heterophylla Michx.

Fort Bennett. H. W. Henshaw.

ARACEÆ.

874. Arisæma Dracontium Schott.

Near Spout Run. E. S. Burgess. Great Falls, on the Maryland side. Lester F. Ward and the author.

LEMNACEÆ.

***879*a*. Lemna gibba** L.

Old canal, foot of Eighteenth and Twentieth streets. Lester F. Ward.

NAIADACEÆ.

884. Najas flexilis Rostk.

Several fruiting specimens were collected in the *Brasenia* pond near Chain Bridge. G. W. Oliver.

887. Potamogeton hybridus Michx.

Alexandria. G. W. Oliver.

***888*a*. Potamogeton Robbinsii** Oakes.

Hunting Creek, Virginia. F. V. Coville.

ORCHIDACEÆ.

900. Orchis spectabilis L.

Several places in the woods above Aqueduct Bridge, on the Virginia shore. The author. Near the first bridge over Rock Creek on Connecticut avenue extended. G. B. Sudworth.

901. **Habenaria tridentata** Hook.

Beyond Silver Hill. G. W. Oliver.

909. **Spiranthes gracilis** Bigel.

Smithsonian Park. Piney Branch. Eastern Branch woods. The author.

914. **Tipularia discolor** Nutt.

North Brookland. Robert Ridgway. Fort Myer. The author.

915. **Microstylis ophioglossoides** Nutt.

Sandy Spring road; a single specimen. H. W. Henshaw. Near Blagden's Mill. P. Gauges.

917. **Liparis Lœselii** Rich.

North end of Massachusetts Avenue bridge. G. W. Oliver.

919. **Corallorhiza multiflora** Nutt.

Below Burnt Mills; four specimens in flower in the second week of August. H. W. Henshaw.

HÆMODORACEÆ.

925. **Aletris farinosa** L.

Fort Whipple; above Blagden's Mill. H. W. Henshaw. Silver Hill. G. W. Oliver and M. B. Waite.

IRIDACEÆ.

927. **Iris verna** L.

Bladensburg. M. B. Waite.

LILIACEÆ.

946. **Smilacina stellata** Desf.

About forty specimens in full bloom, besides several younger individuals, were observed on a shaded rock about three miles above Aqueduct Bridge, on the Virginia shore, in the second week of May. The author.

947. **Maianthemum Canadense** Desf.

Swamp near the Reform School. G. W. Oliver.

* 949*a*. **Lilium Philadelphicum** L.

Broad Branch. H. W. Henshaw. Glen Echo. W. H. Abbott.

956. **Melanthium Virginicum** L.

Several specimens brought to Center Market were said to have been collected near Alexandria.

957. **Veratrum viride** Ait.

Like the preceding, brought to the market from near Alexandria.

*961*a*. **Ornithogalum nutans** L.

Rock Creek, Pierce's Mill Run; last week of April. G. Brown Goode and H. W. Henshaw. Meadow east of Foundry Run. F. V. Coville.

COMMELINACEÆ.

983. **Commelina Virginica** L.

Bank near Chain Bridge, on the Virginia shore. H. W. Henshaw.

XYRIDACEÆ.

985. **Xyris flexuosa** Muhl.

Meadow beyond Silver Hill. Swamp near the Reform School. G. W. Oliver.

ERIOCAULONACEÆ.

986. **Eriocaulon decangulare** L.

Silver Hill. G. W. Oliver.

CYPERACEÆ.

986*b*. **Cyperus flavescens** L.

Abundant along streams in the Piney Branch woods. Near Chain Bridge. The author.

994. **Cyperus Michauxianus** Schult.

Pond near Chain Bridge. The author.

998. **Cyperus retrofractus** Torr.

Mount Hamilton. Lester F. Ward and the author. Along the Canal road. The author.

*1003*a*. **Eleocharis olivacea** Torr.

Holmead Swamp; flowering in the last week of September. The author.

*1003*b*. **Eleocharis tuberculosa** R. Br.

Holmead Swamp; abundant. The author.

1010. **Scirpus debilis** Pursh.

Abundant in swamps near Cabin John Bridge. The author.

1017. **Eriophorum Virginicum** L.

Swamp beyond Silver Hill. G. W. Oliver.

*1021*a*. **Rhyncospora cephalantha** Gray.

Holmead Swamp. The author.

*1021*b*. **Rhyncospora macrostachya** Torr.

Accotink, Fairfax County, Virginia. William Hunter.

*1021*c*. **Rhyncospora corniculata** Gray.

Sandy Landing, Maryland. Lester F. Ward.

1022. **Scleria triglomerata** Vahl.

Terra Cotta Swamp. The author. Reform School. G. W. Oliver.

1024. **Scleria pauciflora** Muhl.

Terra Cotta Swamp. Saul's nursery on the Bladensburg turnpike. Along the Anacostia river marsh. The author.

*1024*a*. **Scleria reticularis** Michx.

Holmead Swamp, September. F. V. Coville.

1031*a*. **Carex muricata** L.

Smithsonian Park. The author.

*1031*b*. **Carex divulsa** Good.

North Brookland. The author.

1055. **Carex glaucodea** Port.

Near the Insane Asylum. Lester F. Ward and the author.

1083. **Carex vestita** Willd.

Terra Cotta Swamp. The author.

1093. **Carex stenolepis** Torr.

Common on the flats between Aqueduct and Chain bridges. Swamp near the Insane Asylum. Above Aqueduct Bridge, on the Virginia shore. The author.

GRAMINEÆ.

1101*a*. **Sporobolus vaginæflorus** Torr.

Common in gardens in the northern part of the city. The author.

1112. **Muhlenbergia capillaris** Kth.

Rediscovered in the old locality near Great Falls; flowering in the third week of September. Lester F. Ward and the author.

*1114*a*. **Calamagrostis Canadensis** Beauv.

On the edge of a swamp, Accotink, Fairfax County, Virginia. William Hunter.

1121. **Gymnopogon racemosus** Beauv.

In thickets along the Queen's Chapel road. Lester F. Ward and the author.

1153*a*. **Bromus tectorum** L.

Open, dry hillside near Anacostia. The author.

1158. **Uniola gracilis** Michx.

Terra Cotta Swamp. Lester F. Ward and the author.

***1160*b*. Hordeum pratense** Huds.

Accotink, Fairfax County, Virginia. William Hunter.

***1166*a*. Danthonia sericea** Nutt.

A few specimens collected in June, 1890, west of Tennallytown. G. B. Sudworth.

1185. Panicum microcarpon Muhl.

Rock Creek. Lester F. Ward and the author.

1190. Panicum verrucosum Muhl.

Holmead and Terra Cotta swamps. Lester F. Ward and the author.

***1192*a*. Panicum miliaceum** L.

Monument grounds. The author.

1195*a*. Setaria Italica Kth.

Near Ivy City. G. W. Oliver.

1203. Andropogon macrourus Michx.

Terra Cotta Swamp. Lester F. Ward and the author.

CONIFERÆ.

1207. Pinus pungens Michx.

Johnny Moore Creek, Virginia. Near Woodlawn, Virginia. William Hunter. Barnaby Branch, Soldiers' Home. Lester F. Ward.

***1207*a*. Pinus Tæda** L.

Near Brightwood. B. E. Fernow.

***1207*b*. Pinus glabra** Walter.

A single tree, about 35 feet high, in a ravine near Tennallytown; apparently introduced. G. B. Sudworth.

1210. Pinus Strobus L.

Near Long Bridge. William Hunter.

1211. **Tsuga Canadensis** Carr.

Accotink Creek, Virginia. William Hunter.

FILICES.

1216. **Pellæa atropurpurea** Link.

Causeway between Analostan Island and the Virginia shore. E. S. Burgess. Rock Creek, between Pierce's Mill and Broad Run. G. W. Oliver.

1219. **Woodwardia angustifolia** Sm.

Piney Branch woods. Near the Reform School. Lester F. Ward and the author.

1223. **Asplenium angustifolium** Michx.

Above Blagden's Mill, on the west bank of Rock Creek. G. W. Oliver.

1226. **Camptosurus rhizophyllus** Link.

Mount Vernon. William Hunter.

1239. **Dicksonia pilosiuscula** Willd.

Abundant along Rock Creek. Lester F. Ward and the author.

1245. **Botrychium ternatum** Swz., var. **dissectum** Millde.

In the wood near Aqueduct Bridge, on the Virginia shore. The author.

1247. **Ophioglossum vulgatum** L.

Very plentiful in woods near Bennings. P. Gauges. A single specimen collected near the Reform School. Lester F. Ward and the author.

LYCOPODIACEÆ.

*1248*b*. **Lycopodium alopecuroides** L.

Sphagnum swamp, Henson's Creek. G. W. Oliver.

1248*c*. **Lycopodium annotinum** L.

In the same locality as the preceding. G. W. Oliver.

1249. Lycopodium dendroideum Michx.

Near the Reform School. Lester F. Ward and the author. North Brookland. Robert Ridgway.

1253. Selaginella apus Spring.

Common in Piney Branch woods, Holmead Swamp, Rock Creek, and in the ravines on the Virginia shore, between Aqueduct and Chain bridges. The author. Kalorama. *Chamælirium* Run. E. S. Burgess.

ISOËTEÆ.

***1253*b*. Isoëtes riparia** Engelm.

Hunting Creek, near Alexandria. F. V. Coville.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

PLANTS OF THE PRIBILOF ISLANDS, BERING SEA.*

BY DR. C. HART MERRIAM.

WITH CRITICAL NOTES BY J. N. ROSE.

INTRODUCTORY NOTE.

The present incomplete list of the plants of the Pribilof or Seal Islands is based on specimens collected by me from July 28 to August 10, 1891, and presented to the National Herbarium in the United States Department of Agriculture. The collection consists of about 1,000 specimens in good condition, comprising upwards of 130 species. Several collections of plants have been made on the islands before, but owing to the constant fogs were ruined by dampness and mould before reaching Washington. My plants were dried by artificial heat and kept in a dry place on the United States Fish Commission Steamer 'Albatross' until their arrival at Puget Sound, whence they were transmitted promptly to Washington by rail.

So far as I am aware, no previous list of the plants of these islands has appeared, though the Pribilof Islands are mentioned as a locality under a number of species in 'Flora Rossica,' and Townsend enumerates 12 species that were brought back by him and identified by Dr. George Vasey.† The present list cannot be anything like complete, since I was on the islands altogether only two weeks and botanizing was incidental to more urgent duties; moreover, only limited parts of the islands were traversed, and the date (end of July and early August) was so late that many plants were past flowering. On several rambles I had the good fortune to be accompanied by Mr. James M. Macoun, of the Geological and Natural History Survey of Canada, who will doubtless supplement my list by many additional records, particularly from St. George Island, where my opportunities for collecting were reduced to a minimum. No collecting was done on Walrus or Otter Islands.

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* Read before the Biological Society of Washington, May 28, 1892.

† Cruise of the *Corwin* for 1885, 1887, p. 97.

ACKNOWLEDGMENTS FOR THE DETERMINATION OF SPECIES.

The majority of the flowering plants were identified by me on the islands. The entire collection on its arrival in Washington was examined by Dr. George Vasey, Botanist of the United States Department of Agriculture, and was turned over by him to Mr. J. N. Rose, Assistant Botanist, for critical study. Mr. Rose has gone over the collection, verifying and supplementing my determinations, and has contributed critical notes on four species, which are inserted in brackets over his initials. Special groups have been submitted to specialists for determination as follows: The *willows* have been identified by Dr. M. S. Bebb; the *grasses* by Dr. George Vasey; the *Carices* by Prof. L. H. Bailey; the *Juncaceæ* by Mr. F. V. Coville; the *mosses* except the *Sphagnums* by Mrs. E. G. Britton, Mr. John M. Holzinger, and Dr. V. F. Brotherus, of Helsingfors, Finland; the *Sphagnums* by Dr. C. Warnstorf, of Neuruppin, Germany; and the *Hepaticæ* by Prof. L. M. Underwood. Six species of mosses collected on St. Paul Island by Mr. Macoun during our visit have been described as new by Dr. H. C. Kindberg.*

BRIEF DESCRIPTION OF THE PRIBILOF ISLANDS WITH SPECIAL REFERENCE TO THEIR VEGETATION.

The Pribilof group in Bering Sea is about 350 kilometers (220 miles) north of the Aleutian Chain, and comprises the islands St. Paul and St. George, separated by about 64½ kilometers (40 miles) of sea, and two islets known as Walrus and Otter Islands, near St. Paul. St. Paul is the largest, measuring about 23½ kilometers (14 miles) in length by 12 kilometers (7½ miles) in greatest breadth; St. George is a little less than 19.3 kilometers (12 miles) in length by a little more than 8 kilometers (5 miles) in greatest breadth. The highest land is on St. George, where a precipitous cliff fronting the sea and a hill in the interior exceed 275 meters (900 feet). The highest land on St. Paul is a little over 183 meters (600 feet). The group is of volcanic origin, and the general surface is rolling, with precipitous cliffs along the water front in many places, alternating with broad valleys and basins. The cliffs predominate on St. George. In summer the islands are almost constantly enveloped in fog; the atmosphere is saturated (the wet and dry bulbs registering the same), and the temperature is uniformly low, the thermometer ranging from 7° C. (= 45° F.) to 9° C. (= 48° F.) or rarely 10° C. (= 50° F.). A good many snow-banks were conspicuous on St. George at the time of our visit, and a few remained in sheltered places on St. Paul. Level moss-bogs and small fresh-water ponds abound, but the greater part of each island consists of extensive stretches of sloping or hilly land thickly strewn with volcanic rocks ½ meter to 2 meters (1½ to 6 feet) in diameter, with innumerable pit-holes between them.

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* Ottawa Naturalist, vol. v, p. 179; separates issued January 12, 1892.

On nearing the islands, if the fog lifts a little, the visitor is impressed by the luxuriance and intensity of color of the deep-green or yellowish-green vegetation which completely covers the surface, as in the case of the less precipitous slopes of the Aleutian Chain. This vegetation consists chiefly of rank grass and bog-moss, interspersed with multitudes of beautiful and showy flowers, which are numerous enough to give color to large areas. There is not a tree or bush on either island, and the highest woody plant—a dwarf willow (*Salix reticulata*)—hardly reaches the height of 75 mm. (3 inches) above the moss-bed in which it grows. Many of the side hills and flats are buried waist deep in a dense growth of rank rye grass (*Elymus mollis*) and cow parsnip (*Heracleum lanatum*), called 'poochka' by the native Aleuts. A coarse but pleasing lupine (*Lupinus nootkatensis*), averaging nearly 1 meter (3 feet) in height and very bushy, is abundant in most parts of the islands, often growing in company with the handsome monkshood (*Aconitum delphinifolium*), which, together with the beds of *Polemonium cæru-*

leum, cover nearly half the green carpet with blue and purple blossoms. Interspersed among the blue flowers just mentioned, and frequently forming large patches by itself, is the pink or pinkish-purple *Pedicularis langsdorffii.* Then there are acres of the showy Alaska poppy (*Papaver nudicaule*), the individual plants standing near enough together to give a delicate yellow glow to the areas they cover. In places the moss and heather bogs are blue from the abundance of blue bells (*Campanula lasiocarpa*), whose disproportionately large flowers actually recline on the moss through which their short stems rise, while another species of the same genus (*C. pilosa*) is inconspicuous and easily overlooked. Other bogs are covered with the deep yellow flowers of *Geum rossii.* A blue violet (*Viola langsdorfii*), a blue and white gentian (*Gentiana frigida*), a spring beauty (*Claytonia arctica*), the Alaska oxeye (*Chrysanthemum arcticum*), a dwarf cornel (*Cornus unalascensis*), and the pretty white star-flower (*Trientalis arctica*) are common in places on the moss-bogs, and sometimes grow in the grass also. Beds of *Omphalodes nana chamissonis* and *Silene acaulis* are common in spots, especially about Bogoslof hill and Polavina, but were mostly past flowering at the time of my visit. Several species of saxifrage are common, the most conspicuous being *S. hirculus*, whose rich, deep-yellow blossoms are much admired.

The raspberries are represented by two dwarf species, *Rubus stellatus* and *R. chamæmorus;* the former was in full bloom and the latter in fruit. The beautiful sea vetch (*Lathyrus maritimus*) abounds in a few spots, but is not generally distributed, and the showy lungwort (*Mertensia maritima*) is common at Northeast Point on St. Paul, and was found sparingly in a few other places, always along the shore. *Primula nivalis* is common in a depression at the mouth of a large cave on Bogoslof hill, but was not found elsewhere on St. Paul.

Ferns are rather scarce, though several species occur. The prevailing moss of the moss-bogs is *Racomitrium lanuginosum. Sphagnum* is scarce on St. Paul, but common on the low bogs of St. George. Heather (*Empetrum nigrum*) abounds on both islands, forming extensive beds—sometimes pure, but usually mixed with moss. Its black umbilicated berries were ripening early in August. Two species of *Lycopodium* occur, but are not common.

LIST OF PLANTS COLLECTED ON THE PRIBILOF ISLANDS IN JULY AND AUGUST, 1891.*

Anemone richardsoni Hooker.

Flowering specimens collected on St. Paul August 7. Not common.

Ranunculus flammula reptans Meyer.

Common about the edges of fresh-water ponds on St. George. Collected in flower August 10.

Ranunculus eschscholtzii Schlecht.

Found in flower among rocks near Bogoslof hill, St. Paul, August 7.

Ranunculus hyperboreus Rottb.

Found in flower on both St. Paul and St. George.

Aconitum delphinifolium Reich.

Abundant on both islands; in full bloom during the latter part of July and early August. Those growing in the moss-bogs are smaller and more delicate than those on higher and drier ground.

Papaver nudicaule Linn.

Abundant on both islands; sometimes scattered here and there in the grass among other equally conspicuous flowers, but often growing in large beds on the moss and heather bogs, covering acres with handsome yellow flowers, which are of large size; at height of blooming the last week of July; petals falling early in August.

Cardamine hirsuta Linn.

Abundant on both islands.

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* Respecting the localities assigned, it should be borne in mind that most of the collecting was done on St. Paul Island; hence a large number of the species here attributed to St. Paul alone doubtless occur in equal abundance on St. George.

Draba incana Linn.

Tolerably common on St. Paul.

Cochlearia officinalis Linn.

Common on St. Paul; in full flower.

Cerastium alpinum Linn.

Common on both islands; in full flower.

Cerastium arvense Linn.

Collected on St. Paul Island by Townsend in 1885 and identified by Dr. Vasey.

Viola langsdorfii Fischer.

Common on both islands; at height of flowering about the end of July.

Silene acaulis Linn.

Common in small patches, particularly on rocky hillsides; past prime.

Lychnis apetala Linn.

Common on St. Paul.

Stellaria crassifolia Ehrh.

Collected on St. George August 10.

Stellaria humifusa Rottb.

Rather common on St. Paul.

Stellaria media Smith.

Common on St. Paul.

Arenaria macrocarpa Pursh.

Abundant on the heather and moss bogs on both islands. Flowers large, white.

Arenaria peploides oblongifolia Watson.

Common in moss bogs near Polavina on St. Paul.

Sagina linnæi Presl.

Common on both islands.

Claytonia arctica Adams.

Common on St. Paul; in full bloom the end of July.

Montia fontana Linn.

Tolerably common on St. Paul.

Lupinus nootkatensis Donn.

Very abundant and conspicuous on both islands; grows high and rank; flowers past prime before end of July.

Lathyrus maritimus Bigel.

Common in a few places on St. Paul; in full flower July 30.

Rubus chamæmorus Linn.

Abundant on both islands, particularly on the heather bogs. Fruit full grown but imperfect and not ripe the latter part of July.

Rubus stellatus Smith.

Common on the heather bogs of both islands. In full bloom the latter part of July; flowers deep, rich red.

Geum rossii Seringe.

Abundant on both islands and growing in the moss bogs in patches a meter or two in diameter. A little past prime in early August. The deep yellow flowers are showy and handsome.

Potentilla fragiformis Willd.

Common on St. Paul; past prime.

Potentilla palustris Scop.

Common in some of the sphagnum bogs on St. George; in flower the first week in August.

Saxifraga bracteata Don.

Common on St. Paul.

Saxifraga chrysantha Gray.

Common in places near Bogoslof hill on St. Paul. Its rich yellow flowers are conspicuous, though considerably smaller than those of *S. hirculus.*

Saxifraga hieracifolia Waldst. & Kit.

Common in places on St. Paul.

Saxifraga hirculus Linn.

Common in patches in the Polavina moss-bogs. Flowers large, yellow, and handsome.

Saxifraga stellaris comosa Willd.

Collected on St. George August 10.

Saxifraga unalaskensis Sternb.

Collected on Polavina moss bogs August 8.

Chrysosplenium ———.

Collected on Bogoslof hill, St. Paul Island, August 7, 1891.

[Acaulescent or with a single leaf, 1 to 3 inches [25–75 mm.] high, pubescent, purplish; radicle leaves on petioles nearly as long as the stems, pubescent; blade oval, 3 to 5 lines [6–10 mm.] broad, 4- to 5-crenate, nearly glabrous; involucral leaves several, shortly petioled, entire or 3-crenate, longer than the flowers; calyx purple, 3 lines [6 mm.] broad, 4-lobed; stamens 8, half as long as sepals; disk prominent. St. Paul Island, Pribilof group. August 7, 1891. Collected by C. Hart Merriam. It seems nearest *C. alternifolium.* The variety *tetrandrum*, to which all our North American forms have been referred, has smaller greenish flowers, 4 stamens, and more leafy stems.—J. N. Rose.]

Hippurus vulgaris Linn.

Tolerably common on St. George.

Epilobium anagallidifolium Lam.

Collected on St. George August 10.

[A peculiar form [100–125 mm.] 4 to 5 inches high, erect; peduncle 1½ to 2 inches long [38–50 mm.]; capsule single or in pairs. Dr. Wm. Trelease thinks it must be "the more erect long-pedicelled form" of this species.—J. N. R.]

Heracleum lanatum Michx.

Abundant on both islands; very large and rank, averaging more than a meter (3 feet) in height. In full flower early in August. This plant is called 'poochka' by the natives, who eat the stalks raw after peeling as we peel pie plant; it is not at all bad.

Ligusticum scoticum Linn.

Rather common.

Cœlopleurum gmelini Ledeb.

Common and rank.

Cornus unalaskensis Ledeb.

Not common or generally distributed. Tolerably common on the moss bogs at Polavina and near Bogoslof hill, on St. Paul, and in places on St. George. In full flower early in August.

Valeriana capitata Pallas.

Tolerably common; past prime before the end of July.

Valeriana sylvatica Banks.

Collected on St. Paul Island by Townsend and identified by Dr. Vasey.

Achillea millefolium Linn.

Common on both islands.

Aster sibiricus Linn.

Common on a moss bog on St. Paul, between the village and Polavina. In full flower early in August.

Chrysanthemum arcticum Linn.

Common in places on both islands, usually in moss bogs; at height of flowering early in August.

Artemisia globularia Cham.

Common in places on St. Paul, particularly about Polavina. St. Paul is the type locality of this species.

[It has rarely been collected, and until now has been a desideratum in the National Herbarium.—J. N. R.]

Artemisia norvegica pacifica Gray.

Specimens determined by Mr. Rose as belonging to this subspecies were collected on both St. Paul and St. George, although the forms inhabiting the different islands are distinguishable.

[The type form of *A. norvegica*, or at least the Rocky Mountain plant which passes as such, is common upon St. Paul. Gray, in the Synoptical Flora, does not extend the range of the species so far north. The stems are [200–305 mm.] 8 to 12 inches high, nearly erect, and very villous (as are also the leaves) except near the base. On St. George occurs a nearly glabrate form, which answers to the var. *pacifica*.—J. N. R.]

Artemisia vulgaris tilesii Ledeb.

Collected near Bogoslof hill, on St. Paul, and near the village on St. George.

[On St. George Island occurs *A. vulgaris*, var. *tilesii*, but the heads are so much larger than *A. vulgaris* that I am inclined to the opinion that this form should have been kept distinct. The form from St. Paul Island, although similar, has somewhat smaller leaves, and these are white-lanate on both sides.—J. N. R.]

Petasites frigida Fries.

Tolerably common on St. Paul; past flowering by August 1.

Senecio pseudo-arnica Less.

Common on St. Paul; just coming into flower the first week in August.

Taraxacum officinale lividum Koch.

Not very common on St. Paul; in flower early in August.

Campanula lasiocarpa Cham.

Common in places on St. Paul, particularly in the drier moss plains; flowers large and handsome.

Campanula pilosa Pallas.

Not common and easily overlooked. Found only between the village and Polavina on St. Paul; in full flower in early August.

Armeria vulgaris Willd.

Common in beds on both islands; past prime.

Primula nivalis Pallas.

Common in a depression at the mouth of Bogoslof cave; not found elsewhere on St. Paul. Common in places on St. George. Nearly past flowering by the end of July.

Androsace chamæjasme Host.

Common on both islands, but nearly out of flower by the end of July.

Trientalis europæa arctica Ledeb.

Tolerably common, but scattering; in full flower the latter part of July.

Gentiana tenella Rottb.

Collected on St. Paul by Townsend and identified by Dr. Vasey.

Gentiana frigida Hænke.

Common and showy on some of the moss bogs near Bogoslof and Polavina on St. Paul; at height of bloom about August 10.

Gentiana glauca Pallas.

Mr. Macoun tells me he found this gentian on St. George.

Polemonium cæruleum Linn.

Abundant on both islands, flowering profusely, and often covering large areas; past prime by the first week in August.

Omphalodes nana chamissonis Herder.

Common in small patches on Bogoslof hill, St. Paul, but nearly out of flower by the first of August.

Mertensia maritima Don.

Common at Northeast Point and along some of the gravel beaches elsewhere on St. Paul. In full flower the latter part of July.

Pedicularis langsdorffii Fisch.

One of the most abundant and conspicuous plants on both islands. Grows in large patches and presents such a diversity of forms as to suggest several species. Flowers past prime by end of July.

Gymnandra gmelini Cham. & Schl.

Collected at the mouth of Bogoslof cave on St. Paul August 7, where it was common and past prime.

Oxyria reniformis Hooker.

Rather common in places, particularly about Bogoslof hill on St. Paul.

Polygonum viviparum Linn.

Abundant on both islands; past prime.

The willows have been determined by Mr. M. S. Bebb as follows:

Salix arctica Pallas.

Collected on Polavina moss bogs, St. Paul, August 8.

Salix phylicoides And.

Collected at Bogoslof hill, St. Paul, August 7.

Salix reticulata Linn.

Abundant on both islands, growing in dense mats on the bogs. Though the branches are long, they are prostrate and buried in the moss, so that the highest leaves rarely reach more than 70 or 80 mm. (2¾ or 3 inches) above the general surface of the bog.

Salix [intermediate between *S. arctica* and *S. ovalifolia*—may possibly be a hybrid.—M. S. Bebb.]

Collected July 30 on St. Paul.

Empetrum nigrum Linn.

Abundant on both islands and forming the covering of large areas. It sometimes forms pure heather bogs, but more often is mixed with moss, usually *Racomitrium.*

Fritillaria kamtschatcensis Ker.

Common on St. George between Zapadnie and the highest part of the island; not seen on St. Paul.

The rushes (*Juncaceæ*) have been determined by Mr. F. V. Coville as follows:

Luzula arcuata unalaschkensis Buchenau.

Collected on St. George Island.

Luzula confusa latifolia Buchenau.

Common on St. Paul.

Luzula campestris sudetica Celakovsky.

Common on St. Paul.

The sedges (*Cyperaceæ*) have been determined by Prof. L. H. Bailey as follows:

Carex alpina Swartz (form).

Collected on St. George Island August 10.

Carex cryptocarpa Meyer (form).

Common on Polavina, St. Paul.

Carex norvegica Schk.

Common with the last species.

Carex rigida bigelovii Tuckerman (= **C. hyperborea** Drejer).

Common on St. Paul.

The grasses have been determined by Dr. George Vasey as follows:

Phleum alpinum Linn.

Common on both islands.

Alopecurus alpinus Linn.

Collected on St. Paul Island.

Alopecurus macounii Vasey.

Collected on St. George Island.

Arctagrostis latifolia Griseb.

Collected on St. Paul Island.

Calamagrostis deschampsioides Trin.

Collected on St. Paul Island.

Deschampsia cæspitosa arctica Vasey.

Common on the old seal rookeries.

Arctophila fulva Rupr.

Collected on St. Paul Island.

Poa arctica R. Br.

Collected on St. Paul Island.

Glyceria angustata Fries.

Common on the abandoned parts of the seal rookeries.

Elymus mollis Trin.

Abundant and rank; the tall grass of the islands.

Ferns are rather scarce on the Pribilof Islands. The specimens collected and brought back by me have been mislaid in the National Herbarium and cannot now be found. The same is true of the club-mosses. The following ferns were collected on the Pribilof Islands by Mr. C. H. Townsend in 1885 and identified by Dr. George Vasey (see Cruise of the *Corwin* for 1885, 1887, p. 97):

Polypodium vulgare Linn.

Aspidium spinulosum Swartz.

Aspidium lonchitis Swartz.

The following species of *Lycopodium* was identified in the field:

Lycopodium selago Linn.

Found sparingly in a few places, particularly on St. George Island.

Mr. John M. Holzinger has kindly undertaken the determination of the mosses. In this he has been assisted by Mrs. E. G. Britton of New York, Dr. V. F. Brotherus of Helsingfors, Finland, and Dr. C. Warnstorf of Neuruppen, Germany. The latter is sole authority for the *Sphagnums*, in the list of which, owing to the peculiarities of the nomenclature employed, the word '*forma*' and the name following are inserted as given by Dr. Warnstorf in order to avoid the use of pure quadrinomials. The *Dicranum* was determined by Prof. C. R. Barnes of Madison, Wisconsin.

In the case of these *Sphagnums* I fear a transposition of labels has taken place, since most of the specimens were collected on St. George Island and only one or two on St. Paul—the latter from Bogoslof hill.

Species and subspecies preceded by an asterisk (*) were collected by Mr. James M. Macoun on St. Paul Island in July and August, 1891, and described as new by Dr. N. C. Kindberg in the Ottawa Naturalist, vol. v, January 12, 1892, p. 179.

Bartramia ithyphylla Brid.

Collected on St. Paul Island.

Bryum arcticum Bruch.

Collected on St. Paul Island.

* **Bryum brachyneuron** Kindberg.

* **Bryum froudei** Kindberg.

Bryum pendulum Schimp.

Collected on St. Paul Island.

Bryum inclinatum Br. & Sch.

Collected on St. Paul Island.

Ceratodon purpureus Brid.

Collected on St. Paul Island.

* **Ceratodon heterophyllus** Kindberg.

Desmatodon systilius Br. & Sch.

Collected on St. Paul Island.

Dicranum elongatum Schleich.

Collected on St. Paul Island.

Hypnum (Calliergon) cordifolium Hedw.

Collected on St. Paul Island.

Hypnum (Pleurozium) splendens Hedw.

Collected on St. Paul Island.

Hypnum (Hylocomium) squarrosum Linn.

Collected on St. Paul Island.

Hypnum (Hylocomium) triquetrum Linn.

Collected on St. Paul Island.

Hypnum (Brachythecium) rivulare Bruch.

Collected on St. Paul Island.

Mnium subglobosum Br. & Sch.

Collected on St. Paul Island.

Oncophorus wahlenbergii Brid.

Collected on St. George Island.

Orthotrichum lævigatum Zelt.

Collected on St. Paul Island.

Orthotrichum microblephare Schimp.

Collected on St. Paul Island.

Philonotis fontana Brid.

Collected on St. Paul Island.

Polytrichum alpinum Linn.

Collected on St. Paul Island.

Polytrichum strictum Banks.

Collected on St. Paul Island.

Racomitrium microcarpon Brid.

Collected on St. Paul Island.

Racomitrium lanuginosum Brid.

Collected on St. Paul Island.

Tetraplodon mnioides Br. & Sch.

Collected on St. Paul Island.

Webera cucullata Schimp.

Collected on St. Paul Island.

* **Webera canaliculata microcarpa** Kindberg.

* **Didymodon baden-powelli** Kindberg.

Sphagnum fimbriatum arcticum Jeus.

Sphagnum fimbriatum arcticum forma **fuscescens** Warnst.

Sphagnum lindbergii microphyllum forma **brachydasyclada** Warnst.

Sphagnum riparium Angstr.

Sphagnum squarrosum imbricatum forma **brachyanoclada** Warnst.

Sphagnum squarrosum semisquarrosum Russ.

The following species of *Hepaticæ* were collected on St. Paul Island and determined by Prof. L. M. Underwood:

Diplophyllum taxifolium Nees.

Herberta adunca S. F. Gray.

Gymnomitrium coralloides Nees.

Cranial Characters.—Compared with *C. ludovicianus* the skull is broader and shorter, with shorter nasal bones, postorbital processes, and zygomatic arches; jugals with antero-inferior angle not only thickened to form a triangular plate, but produced downward so as to overhang and protect from the outside the fossa beneath; horizontal part of jugal broader and shorter; ascending arm of jugal much thinner and not forming a noticeable plate between maxillary and lachrymal; audital bullæ larger and more inflated; basi-occipital narrower; frontal shield more concave; posterior border of inflected angle of mandible more nearly at right agles to axis of jaw (more squarely truncated); dentition less massive; anterior face of incisors strongly yellow (instead of white or faintly straw-colored); upper incisor with an indistinct groove in front of the inner half.

The length of the nasals equals the distance from the anterior lip of the foramen magnum to the posterior edge of the palate. In *C. ludovicianus* the nasals are much longer.

In cranial characters *C. ludovicianus arizonensis* of Mearns, from southern Arizona, is in some respects intermediate between true *ludovicianus* and *mexicanus*, especially in the unusual development of the triangular plate of the jugal, size of the audital bullæ, and breadth of basi-occipital. In the other cranial characters here pointed out, *C. mexicanus* differs from *C. l. arizonensis* as much as from *C. ludovicianus* proper.

Measurements of Specimens Collected of Cynomys mexicanus.

U. S. National Müseum No.		Original No.	Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Hind foot.
Skin.	Skull.							
26426	33839	622	La Ventura, Coahuila, Mexico.	Mar. 24, '91	♂	430	106	64
26422	33835	623	.....do	...do	♂	422	114	62
26429	33842	624	.....do	...do	♂	415	102	59
26423	33836	625	.....do	...do	♂	419	107	63*
26428	33841	626	.....do	...do	♂	415	103	61
26425	33838	627	.....do	...do	♀	390	94	62
26421	33834	628	.....do	...do	♀	400	99	60
26427	33840	629	.....do	...do	♀	392	102	61
26424	33837	630	.....do	...do	♀	398	104	62
26430	33843	631	.....do	...do	♀	383	94	59

* Type.

DESCRIPTION OF A NEW PRAIRIE DOG (CYNOMYS MEXICANUS) FROM MEXICO.*

BY DR. C. HART MERRIAM.

In March, 1891, Mr. Clark P. Streator collected a series of ten skins and skulls of Prairie Dogs at La Ventura, in the extreme southeastern corner of the Province of Coahuila, Mexico, 220 miles south of Laredo, on the boundary between Texas and Mexico. Mr. Streator writes that the colony from which these animals were obtained was the largest he had ever seen. The species proves to be new. It resembles the common Prairie Dog of the Great Plains (*C. ludovicianus*), but differs from it in being somewhat larger and in having a much longer tail. The tail differs further from that of any known Prairie Dog in the extent and intensity of the black on the terminal portion. The black covers the distal half below and forms a submarginal band around the terminal half above, being both more extensive and blacker in color than in *ludovicianus.*

The new species may be known by the following description:

Cynomys mexicanus sp. nov.

Type No. $\left\{\begin{smallmatrix}26423\\33836\end{smallmatrix}\right\}$ ♂ ad. U. S. National Museum (Department of Agriculture Collection). From La Ventura, Coahuila, Mexico, Mar. 24, '91. Collected by Clark P. Streator. (Original No. 625.)

Measurements.—Total length, 419; tail vertebræ, 107; hairs, 24 + [worn off at tips]; hind foot, 63.

General Characters.—The largest species of the genus; similar to *Cynomys ludovicianus*, but larger, with longer and blacker tail.

Color.—Upper parts everywhere grizzled buffy-fulvous, sparsely mixed with long black hairs; under parts and feet buffy. Tail above: concolor with the back, but with a broad submarginal band and tip of black, which reaches back more than half the length of the tail. Tail below: proximal half buffy like belly, washed with fulvous; distal half black, grizzled with buffy, from the color of the basal part of the hairs, which shows through.

The type specimen has not completed the spring molt, and the posterior two-thirds of the back is pale rufus from the wearing away of the light tips of the hairs, bringing the subapical rufus zone to the surface. Most of the specimens have completed the molt.

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* Read before the Biological Society of Washington, May 14, 1892.

A NEW GENERIC NAME FOR THE BERING SEA FUR-SEAL.

BY T. S. PALMER.

In 1859 Dr. J. E. Gray placed the northern Fur-Seal in a distinct genus, which he called *Callorhinus*,[*] and for more than thirty years this name has been almost universally adopted by writers who recognize the generic distinctness of the *Phoca ursina* of Linnæus from the southern Fur-Seals of the genus *Arctocephalus*. The fact seems to have been overlooked, however, that *Callirhinus*[†] had been previously used in entomology by Blanchard, who, nine years before, proposed it as the name of a genus of Coleoptera. In 1857 *Callirhinus*[‡] was again used in herpetology by Girard, who established the genus for a peculiar snake (*Callirhinus patagoniensis*), collected by the Wilkes Expedition on the coast of Patagonia.

Thus the name is preoccupied both in entomology and herpetology, and cannot be used for a genus of mammals. Unfortunately no synonym of *Callorhinus* seems to be available, and it becomes necessary to propose a new generic name for the fur-seal of Bering Sea. The name *Callotaria*[§] is therefore proposed as a substitute for *Callorhinus* of Gray.

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[*] Proc. Zool. Soc., London, 1859, 359.

[†] Cat. Collect. Ent., 1850, 176.

[‡] Proc. Acad. Nat. Sci., Phila., 1857, 182.

[§] *Καλὸς*, beautiful; *Otaria*, a genus of Fur-Seals.

NOTE ON LOWER CAMBRIAN FOSSILS FROM COHASSETT, MASS.*

BY CHAS. D. WALCOTT.

In a bowlder of reddish-brown limestone, picked up by Mr. T. A. Watson on Pleasant Beach, Cohassett, Mass., and forwarded to me for examination by Dr. W. O. Crosby, I found two species of Lower Cambrian fossils—*Straparollina remota* Billings, and *Hyolithes communis* Billings. The original specimens of *Straparollina remota* were found in Smith's Sound, Trinity Bay, Newfoundland, in rocks of Lower Cambrian age. This species is very closely allied to *Pleurotomaria* (*Raphistoma*) *attleboroughensis*, Shaler & Foerste from Attleborough, Mass. The same slender species of *Hyolithes* also occurs associated with the Attleborough form.

It is interesting to note the occurrence of Cambrian fossils in eastern Massachusetts, as every discovery of a species identical with the fauna of Newfoundland strengthens the correlation between the two sections.

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* Read before the Biological Society of Washington, March 19, 1892.

close, simple veins emerging at an acute angle from it. Associated with these leaves were a small number of beautifully perserved leaves, representing an undescribed species of *Thinnfeldia*, which is long-lanceolate in outline, tapering gradually below into a thick petiole and above into a long, slender acuminate apex. The nervation is the same as in the preceding species. In the same beds with these leaves were found two fruiting catkins, at first thought to represent the fruit of the *Thinnfeldia*, but later decided to represent an undescribed species of *Populus*.

Perhaps the most interesting specimens are a number of ferns representing the fruiting condition of what has been called *Sphenopteris lakesii* Lx., one of the most characteristic species of the Denver formation of Colorado, but now shown to be an Aspidium. At least one-tenth of all the specimens in a very large collection of plants from the Denver formation belong to this *Aspidium lakesii* Lx. sp.*

The principal object of this investigation was to ascertain the light thrown by the plants upon the question of the age of the deposits. Lesquereux referred the plants to his Lower Lignitic or true Laramie.* On the other hand, Professor Ward would incline to place them in the Fort Union beds; but it is now known that he included in his enumeration localities in and about the Yellowstone Park which belong to a higher horizon than the Bozeman Coal Field.

Of the 43 species making up this flora, 3 are new to science and 9 others have never been found outside of these beds, leaving 31 species upon which we must depend in determining the age. Of this number 7 species, of which 3 are doubtful, have been found in the Fort Union beds, 14 in the undoubted Denver formation, 12 species at Carbon and Evanston, Wyoming, the age of which may be Denver, and 19 of the species in the true Laramie. By combining the species common to the undisputed Denver and the localities of Carbon and Evanston we have 19 species, or the same number as found in the true or coal-bearing Laramie. From this it appears that there can be no question but that it belongs to what is generally known as the Laramie, but the evidence of the fossil plants is hardly sufficient to permit a separation into the lower and upper divisions or the true Laramie and the recently differentiated Denver formation.

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*All of the new or interesting species will be named, fully described, and illustrated in Bull. U. S. Geological Survey, No. —. In preparation.

* Hayden's Ann. Rept., 1872, p. 409.

THE FOSSIL FLORA OF THE BOZEMAN COAL FIELD.*

BY F. H. KNOWLTON.

[Abstract.]

The first collection of fossil plants from what is now very generally known as the Bozeman Coal Field, Montana, was made in 1871 by the members of Dr. F. V. Hayden's party while they were encamped at Fort Ellis preparatory to beginning their memorable exploration of the Yellowstone National Park. The actual collecting was done by Dr. A. C. Peale, Mr. W. H. Holmes, and Mr. Joseph Savage, and the specimens were all obtained on the same day and from the same vicinity, although not all at exactly the same spot. As the country was at that time new and unsettled, the nearest fixed point was the military reservation of Fort Ellis, and the specimens were labeled by the various collectors as follows: "Six miles above Spring Cañon (now known as Rocky Cañon), near Fort Ellis, Montana;" "Above Spring Cañon, near Fort Ellis," and "Near Fort Ellis, above coal."

These specimens were identified by Prof. Leo Lesquereux, and represent about 30 species, nearly one-third of which were then regarded as new to science.

In recent years quite extensive additional collections have been made, both at the original localities and a number of newly discovered ones, by Dr. Peale, Mr. W. H. Weed, and myself. These, together with most of the original specimens that are fortunately preserved in the United States National Museum, have furnished the basis of the present examination.

As at present understood, the flora of the Bozeman Coal Field embraces 43 species. Of this number 3 are regarded as new to science, while a number of others are of exceptional biological interest.

Thinnfeldia polymorpha Lx., sp , the *Salisburia polymorpha* Lx., of the original collection, is represented by a great number of finely preserved leaves, which are long, wedge-shaped in outline, narrowed from above the middle downward into a strong, thick petiole, and rounded, erose or irregularly undulate or toothed at the apex. The nervation consists of a strong midvein, continuing to or vanishing just below the apex, and numerous thin,

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* Read before the Biological Society of Washington, March 19, 1892.

Among the specimens of *Carcharodon* in the United States National Museum is a very perfect and beautiful tooth, collected by Ira Sayles in the vicinity of Richmond, Va., which agrees very well with Gibbes' description and figure of *C. mortoni*. Although very thick and massive, the specimen presents a curiously distorted and bulged appearance, precisely as if it had been spread out by pressure on the apex of the tooth. On the anterior face are evidences of injury, and from this has undoubtedly resulted the unusual shape of the tooth. The specimen figured by Gibbes has the same unnatural, swollen look as the tooth in the United States National Museum, and there can be no doubt but that it too is a mere abnormality, possibly caused by a similar accident to the tooth while young.

The extreme rarity of examples of *Carcharodon mortoni* is in accord with the supposition that they are merely abnormal teeth, and as lateral cusps are lacking in the few specimens recorded, *Carcharodon mortoni* Gibbes, should stand as a synonym of *Carcharodon megalodon* Agassiz.

VOL. VII, PP. 151-158 JULY, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

ON *CARCHARODON MORTONI* GIBBES.*

BY F. A. LUCAS.

In his Monograph of the Fossil Squalidæ of the United States Gibbes assigns the name *Carcharodon mortoni* to two incomplete teeth, stating that with the exception of a single specimen in the cabinet of F. S. Holmes, of Charleston, he had met with none elsewhere. The species was originally described in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1847, page 266, the descriptions being repeated in the Journal of the Academy for 1848, page 146, and one of the specimens shown in figure 45, plate xxi.

The essential part of the description consists in the statements that "both the outer and inner surfaces are convex and prominent, the latter trebly so," and "the root is immensely thick, an inch and a half, and constitutes more than half the bulk of the tooth." The figure shows the tooth to have been unusually thick and swollen for a tooth of *Carcharodon*, and that the root was irregular in shape.

A. Smith Woodward, in his Catalogue of Fossil Fishes in the British Museum, places *Carcharodon mortoni*, with several other reputed species of the genus, in the list of those "* * * recognized upon the evidence of detached teeth, though it is not improbable that some of the names are synonyms * * *."

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* Read before the Biological Society of Washington, Feb. 20, 1892.

VOL. VII, PP. 159-174 SEPTEMBER 29, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

DESCRIPTION OF A NEW GENUS AND SPECIES OF MURINE RODENT (*XENOMYS NELSONI*) FROM THE STATE OF COLIMA, WESTERN MEXICO.

BY C. HART MERRIAM, M. D.

Among the many interesting mammals recently collected by Mr. E. W. Nelson in western Mexico is a handsome rat-like rodent which seems to be not only an undescribed species, but the type of a new genus. In form and general external appearance it looks like a rather small wood rat of the genus *Neotoma*, but differs from the members of that genus, and in fact from all other known North American murines, in having a large and clearly defined whitish spot over each eye and another (though less conspicuous) below each ear. The upper lips and cheeks also are white more than half way to the eyes, giving the animal a very pretty as well as unusual physiognomy. The color of the back and upper parts generally is deep tawny red or fulvous, while the under parts are creamy white. The skull and teeth present a combination of characters so unlike those of any known rodent that a new genus must be framed for its reception. While resembling *Neotoma* more closely than any other genus, it differs from it in many important characters. With a skull much like that of *Neotoma mexicana*, it has well developed supraorbital beads like *Nyctomys*, large lachrymals, a large interparietal, and large and greatly inflated audital bullæ, which differ from those of any murine with which I am acquainted and resemble those of some of the carnivores. In dentition it combines the 3-rooted upper molars of the true murines with the non-tubercular prismatic grinding crowns of the arvicolines, and has the broadly rounded alternating closed triangles of *Phenacomys*, only even more crowded.

The new genus may be characterized as follows:

Xenomys * gen. nov.

Skull resembling that of *Neotoma* in general form and appearance, but differing in possessing marked elevated and laterally projecting supraorbital beads, much larger and heavier lachrymals, greatly enlarged and inflated audital bullæ, which are elongated antero-posteriorly and parallel to the axis of the skull and to each other, instead of being set obliquely as in *Neotoma* (in which genus they would meet in the middle of the pterygoid fossa if produced forward along their strongly convergent axes). The anterior border of the squamosal above the zygomatic process is marked by a projecting vertical ridge corresponding to the postorbital process of *Cuniculus*, *Myodes*, and *Phenacomys*, and serving to indicate the separation of the (small) temporal from the (large) orbital fossa. Posteriorly the squamosal does not reach the occiput as it does in *Neotoma*, but ends about half-way between the posterior root of the zygoma and the occiput. Its posterior spicule reaches the mastoid. The paroccipital processes are long and stout. The interparietal is very large and somewhat diamond-shaped. The condyloid process of the mandible is long and slender and higher than the coronoid process.

Dental Characters.—Molars truly rooted; the roots closed at the tips; upper molars 3-rooted; lower molars 2-rooted. First upper molar with anterior and posterior roots subcylindric and a broad flat root in the middle on the inner side, the latter slightly notched at the tip and having the appearance of two roots grown together. Between the middle and posterior root in the specimen examined is a small needle-like auxiliary or supplemental root about half the length of the others; middle upper molar with 2 anterior and 1 posterior roots, the anterior on the inner side about double the size of the others; last upper molar with

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* *Xenomys:* from ξένος, strange, and μῦς, mouse.

2 anterior and 1 posterior roots; molar series large and heavy, much broader than in *Neotoma* or *Arvicola*; crowns flat, prismatic, non-tubercular, with broadly rounded and crowded alternating closed triangles as in *Phenacomys* and *Arvicola* (only much more crowded) and bearing no resemblance to the narrow transversely elongated loops of *Neotoma*; crown of last lower molar deeply incised on the inner face a little anterior to the middle by a narrow trenchant reëntrant angle which carries a fold of enamel obliquely forward and outward across the tooth. On the outer side a short reëntrant angle pushes a loop of enamel obliquely forward and inward toward the middle of the long fold from the opposite side, leaving an anterior loop, a posterior loop, and a small closed or nearly closed triangle on the outside about the middle of the tooth. The resulting pattern is shaped like the letter **S**, with a small closed triangle on the outer side of the convexity, thus differing widely both from the 3 transverse loops of *Arvicola* and *Phenacomys* and from the 2 transverse loops or figure-8 pattern of *Neotoma*; upper incisors plane or with a faint bead on each side of the anterior face, which is nearly flat and yellow; lower incisors plane, convex in front, pointed.

In describing genera from single species it is not always possible to distinguish clearly between generic and specific characters, unless indeed the genus is based on a single character. In the event of the discovery of additional species of the present genus it may be found that some of the characters here ranked as generic are only specific or, on the other hand, that some here considered specific are really generic.

The species may be known from the following description:

Xenomys nelsoni* sp. nov.

Type No. $\frac{33281}{45286}$ ♂ ad. U. S. National Museum (Department of Agriculture collection). From Hacienda Magdalena, Colima, Mexico, March 21, 1892. Collected by E. W. Nelson. (Original number, 2288.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 300; tail vertebræ, 143; hairs, 6; hind foot, 30; ear (in dry skin) from crown, 18; from anterior root, 22.

General Characters.—Size about that of a half or two-thirds grown rat, or nearly equaling *Neotoma mexicana;* tail a little shorter than head and body, well haired, particularly above; face ornamented by a distinct whitish spot over each eye and a less distinct one under each ear; color of upper parts rich fulvous; under parts white; ears about half as long as the head and nearly naked (sparsely clothed with fine, inconspicuous hairs); whiskers reaching back to shoulders; fur soft.

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* Named in honor of its collector, Mr. E. W. Nelson.

Color.—Upper parts fulvous or tawny-rufous, palest on the head and brightest over the rump, flanks, and hips; back sparsely mixed with black-tipped hairs; an ill-defined dusky ring around each eye, above which is a whitish spot about as large as the eye itself; a less distinct whitish spot just below the inferior root of the ear; upper lips white, the white color extending up on the cheeks more than half way to the eyes; sides of face below eyes and ears washed with fulvous, whiskers blackish; tail concolor, dark umber-brown all round; upper surfaces of feet whitish, more or less clouded with dusky (varying considerably in the three specimens); under parts creamy white to the very roots of the hairs except along the sides of the belly, where the basal part of the fur is plumbeous; line of demarkation between colors of upper and lower parts everywhere sharp and distinct.

An immature but full-grown specimen from Armeria, Colima (collected March 2, 1892), has a small whitish lanuginous tuft in front of the anterior base of each ear, in addition to the markings of the specimens from Hacienda Magdalena, already described. This may be characteristic of the winter pelage. The same specimen has white feet, and the white of the face is more extensive.

Cranial Characters.—The principal cranial peculiarities have been pointed out in the generic description. The great size of the audital bullæ is doubtless a specific character, though not the direction of their axes. The bullæ are broader anteriorly than posteriorly, and curve slightly outward in front of the meatus, where the inflated portion is much more extensive than that behind it. The large size of the interparietal also is in all probability a specific feature. In one of the three skulls its antero-posterior diameter along the median line equals that of the parietals. The ascending branches of the premaxillaries reach as far back as the nasals, which end on a line with the lachrymals.

Dental Characters.—(The generic characters already mentioned are not repeated here.) First upper molar with crown more than half as broad as long; outer side straight; inner side strongly convex, with one anterior and one posterior closed loop, and one external and two internal lateral closed triangles. Middle and last upper molars each with one anterior and one posterior closed loop, and one lateral closed triangle on each side (sometimes the lateral triangles are not quite closed in the last tooth). The anterior loops of the second and third upper molars are strongly pyriform, as in *Phenacomys.*

First lower molar with anterior half bent strongly outward, the anterior loop looking outward instead of forward. This tooth has an anterior loop, a posterior loop, an external lateral closed triangle, and two internal lateral triangles, the posterior of which is closed. Second lower molar with one anterior and one posterior closed transverse loop, and one lateral closed triangle on each side; last lower molar with an anterior oblique closed loop, a posterior oblique closed loop, and a lateral closed (or nearly closed) triangle on the outer side. (This tooth is described more in detail in the generic diagnosis.)

Haunts and Habits.—Almost nothing is known of the life history of this interesting and heretofore unknown animal. Respecting the specimens from Hacienda Magdalena Mr. Nelson writes: "Not common. The two specimens obtained were caught in hollow trees." Another "was taken in the low dense woods near the mouth of the Armeria River. They live in hollow trees."

Measurements (taken in flesh) of Xenomys nelsoni.

U. S. National Museum No.		Original No.	Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Hind foot.
Skin.	Skull.							
33280	45285	1972	Armeria, Colima, Mexico.	Mar. 2, '92	♂	315	155	31
33281	45286	2288	Hacienda Magdalena, Colima, Mexico.	Mar. 21, '92	♂	300	143	30*
33282	45287	2318	Hacienda Magdalena, Colima, Mexico.	Mar. 23, '92	♂	335	170	32

*Type.

DESCRIPTIONS OF NINE NEW MAMMALS COLLECTED BY E. W. NELSON IN THE STATES OF COLIMA AND JALISCO, MEXICO.

BY C. HART MERRIAM, M. D.

The well known ornithologist, Mr. E. W. Nelson, whose zeal and indefatigable energy have led him to penetrate many remote and little-known regions for the purpose of collecting mammals and birds, and whose efforts have been rewarded by the discovery of many new species—from the Arctic regions as well as the arid deserts and lofty mountains of the United States—has recently directed his steps into Mexico, in the interest of the United States Department of Agriculture.

Diagnoses are here given of nine new mammals contained in the collections sent by him from Colima and Jalisco, in addition to the new genus and species just described (*Xenomys nelsoni*).* Illustrations of cranial and dental characters will appear in a later paper.

Genus **Geomys.**

The collection contains three new pocket gophers of the genus *Geomys:* a small species from the high mountains of Jalisco (*G. nelsoni*); a large species from the plain of Colima (*G. fumosus*), and a large species from the valley of Zapotlan (*G. gymnurus*). They may be known from the following descriptions:

Geomys nelsoni sp. nov.

Type No. $\frac{33587}{45622}$ old ♂. U. S. National Museum (Department of Agriculture collection). From north slope of the Sierra Nevada de Colima, Jalisco, Mexico (altitude 1,980 meters, or 6,500 feet), April 11, 1892. Collected by E. W. Nelson. (Original number, 2436.)

Measurements (in millimeters, taken from dry skin of type, slightly overstuffed; this is the largest and oldest of the seven specimens).—Total length, 250; tail vertebræ, 80; hind foot, 30.

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* Proc. Biol. Soc. Wash., vol. vii, Sept., 1892, pp. 159–163.

Cranial Measurements.—Total length of skull of type, 42; basilar length (inferior lip of foramen magnum to posterior rim of alveolus of incisor), 35; zygomatic breadth, 25; upper molar series on alveolæ, 9.

General Characters.—Upper incisors bisected by a median sulcus; size smallest of the known species; nose with a vertically elongated naked pad or callosity, above which the hairs are short, stiff, with the tips worn off; tail rather long and naked; claws moderate; color deep and bright chestnut above and below, much deeper than in *Geomys tuza* from Florida and the eastern Gulf region. An immature but full-grown specimen (No. 33585) is dusky in color, and one in the molt has the anterior parts chestnut and the posterior dusky.

Cranial Characters.—*Geomys nelsoni* differs so widely from any of the species having the upper incisors bisected by a single groove that detailed comparison is hardly necessary. Contrasted with *G. clarkii* from the Rio Grande region, it may be distinguished at a glance by its much smaller size, more squarely truncated zygomatic arches, absence of triangular plate at the antero-inferior angle of the zygomatic arch, relatively longer and more slender nasals, smaller and more smoothly rounded audital bullæ, and mastoids which occupy much less space on the occipital plane, where they present a subquadrangular surface.

Mr. Nelson states that the species "was found only in some fields at the upper ranch at the foot of the main north slope of the Sierra Nevada de Colima, Jalisco, in the upper border of the lower pine belt, at about 6,500 feet altitude, where it was common, and was found in company with the large species" [here described as *Geomys gymnurus*]. Seven specimens were secured.

Geomys fumosus sp. nov.

Type No. $\frac{33202}{45207}$ ♂ ad. U.S. National Museum (Department of Agriculture collection). From Colima City, Mexico, March 27, 1892. Collected by E. W. Nelson. (Original number, 2338.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 292; tail vertebræ, 80; hind foot, 41.

General Characters.—Size medium, about equalling *G. bursarius;*

upper incisors with a single median sulcus; pelage coarse, but not nearly so harsh as in *G. hispidus;* fore claws rather weak for a *Geomys;* tail appearing naked, but sparsely sprinkled with a few inconspicuous hairs; hind feet nearly naked; belly scant haired, the skin showing through; no nasal pad. *Geomys fumosus* seems to be more closely related to *Geomys hispidus* than to any other known member of the genus, but it is smaller than *hispidus;* much darker in color; the sulcus in the upper incisor is median instead of lateral; the cranium is much narrower and less flat interorbitally, and the angular processes of the mandible are conspicuously longer and project out laterally to a much greater distance.

Color.—Upper parts dark sooty brown, the tips of the hairs faintly washed in places with reddish brown; under parts indistinctly paler.

Mr. Nelson contributes the following information respecting the haunts of this species: In the vicinity of Armeria, at an altitude of about 200 feet above the sea, a few pocket gopher's hills were found, but none of the animals were taken. From there up the course of the Armeria river on the plain of Colima the hills become more and more numerous until from about 800 to 2,500 feet they are common in places. In a flat overgrown with wild fig, mesquit, and cocoanut palm trees near Colima City I secured eleven of these animals. They seem to live in isolated and limited colonies, between which, in apparently equally favorable ground, they occur singly and rarely. One colony of considerable size occupies an open grassy area in the limestone belt between Colima and the volcano. Others were seen along the sandy border of the Armeria river bottom, where a growth of low bushes had started up, and another in some thick thorny woods on a dry bench bordering the Colima river a few miles below the city.

Geomys gymnurus sp. nov.

Type No. $\frac{33579}{45614}$ ♀ ad. U. S. National Museum (Department of Agriculture collection). From Zapotlan, Jalisco, Mexico, April 16, 1892. Collected by E. W. Nelson. (Original number, 2460)

Measurements (in millimeters, taken in flesh by collector).—Total length, 342; tail vertebræ, 93; hind foot, 50.

General Characters.—Size very large, about equalling *G. mexicanus*, but differing conspicuously from that species in having the tail naked instead of hairy. Upper incisors with a single median furrow. Color of type and other specimens from the Zapotlan valley, uniform reddish brown with a dusky or fuliginous patch behind each ear and a larger one on the nose. Specimens from the base of the neighboring mountains (Sierra Nevada de Colima, Jalisco), here referred to the same species, are much darker, and two from high altitudes are uniform dark sooty-plumbeous. The latter, Mr. Nelson states in his notes, occur in company with the small species here described as *Geomys nelsoni*.

The skull of this species is huge, and the under jaw in particular bears a striking superficial resemblance to that of *Aplodontia*. The angular processes project out laterally to a considerably greater distance than in *Geomys mexicanus*.

Genus **Neotoma**.

The collection contains a series of two heretofore unknown species of *Neotoma*. The first of these, obtained at Manzanillo, in the state of Colima, is the largest and handsomest species known, and I take pleasure in naming it *Neotoma alleni*, after Dr. J. A. Allen, of the American Museum of Natural History, in New York, in recognition of his valuable contributions to the mammalogy of Mexico. It is remarkable that so large and conspicuous an animal should have escaped description until the present time, particularly since it is common in the immediate neighborhood of one of the principal seaports of western Mexico. In the pattern of the enamel folds of the last lower molar it differs conspicuously from typical *Neotoma*, as pointed out in detail beyond, and may merit subgeneric recognition. It is represented by more than 20 specimens in excellent condition.

The other species (*N. tenuicauda*) is much smaller, less than half the size of *N. alleni*, and was obtained in the Sierra Nevada de Colima, in the state of Jalisco. It is represented by seven specimens.

The two species may be known from the accompanying descriptions:

Neotoma alleni sp. nov.

Type No. $\frac{32709}{44632}$ ♂ ad. U. S. National Museum (Department of Agriculture collection). From Manzanillo, Colima, Mexico, January 26, 1892. Collected by E. W. Nelson. (Original number, 1796.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 472; tail vertebræ, 225; hairs, 4; hind foot, 46; ear (in dry skin) from anterior root, 29.

General Characters.—Size much larger than any species heretofore described; ears rather large and sparsely clothed with fine hairs on the posterior surfaces; tail shorter than the head and body, blackish, sparsely haired, the annulations and scales distinctly visible above as well as below; upper parts deep tawny-red or rusty.

Color.—Upper parts from forehead to base of tail deep fulvous or tawny-ferruginous; nose and sides of face mouse-gray, tinged with bluish in some specimens; under surface whitish, the tips of the hair only being white and the plumbeous basal portion showing through; upper surfaces of feet whitish, more or less clouded with dusky; tail blackish all round.

Cranial Characters.—Skull largest of the genus. Total length of type, 53; basilar length (from inferior lip of foramen magnum to posterior alveolus of incisor), 44; zygomatic breadth, 27.50; length of upper molar series on alveolus, 11; cranium strongly marked by muscular impressions; superciliary ridge strongly elevated and continued posteriorly across the outer half of the parietals and interparietal to the occiput; interparietal subquadrate with a postero-lateral wing on each side; ascending ramus of premaxillary short, barely reaching plane of lachrymals, and but slightly exceeding the nasals; antorbital slit with a tubercle at inferior base; audital bullæ small, connected by a bony process with the hamular processes of the pterygoids; molar series very large and heavy, about one-fourth the basilar length of the skull; first and second upper molars with a lateral closed triangle on each side; last lower molar shaped like the letter **S**, as in *Xenomys*, but differing from *Xenomys* in having a shallow reëntrant angle on the outer side opposite the deep fold from the inner side; infracondyloid notch of mandible broadly open and but slightly concave.

Mr. Nelson writes that in the neighborhood of Manzanillo this large and handsome wood rat "is abundant everywhere on the lower parts of the wooded hill slopes and adjacent dry ground covered with mesquite and other seed-bearing trees. It is strictly nocturnal, and usually lives in holes or burrows at the foot of a tree or under some convenient shelter, from which its pathway or trail, neatly cleared of brush, leaves, and twigs, leads away. It lives also in ledges of loose rock, and in a few such places small collections of sticks, shells of land crabs, and other *Neotoma* bric-a-brac were found. These were rare, however. Where the animals are common these trails intersect one another and form a network on the brush and tree-covered slopes. Sometimes their runways reach down on the low wooded flats close to the coast, but they are not common in such places."

Neotoma tenuicauda sp. nov.

Type No. $\frac{33594}{45629}$ ♂ ad. U. S. National Museum (Department of Agriculture collection). From north slope of the Sierra Nevada de Colima, Jalisco, Mexico (altitude 3,650 meters, or 12,000 feet), April 13, 1892. Collected by E. W. Nelson. (Original number, 2446.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 340; tail vertebræ, 160; hind foot, 31.

General Characters.—Size smallest of the known species, being slightly smaller even than *N. mexicana;* tail *slender* and sparsely haired, bicolor; ears rather small, sparsely haired; fore feet soiled white; hind feet whitish, clouded with dusky.

Color.—Upper parts dark brown, more or less suffused with yellowish fulvous, particularly on the neck and shoulders, passing into dark fulvous on the flanks and hips; under parts soiled white (the plumbeous basal color showing through), with a salmon patch on the inner side of each axilla; tail bicolor, dusky above and whitish below; fore feet and ankles soiled white; hind feet whitish, strongly clouded with dusky proximally (the dusky fading out in passing over the metatarsals); toes pure white.

Cranial and Dental Characters.—Nasals rather short, not reaching plane of lachrymals. ascending rami of premaxillæ ending on plane of lachrymals; audital bullæ rather large for a *Neotoma;* molar series narrow, with sharply angular prisms; first upper molar with an internal lateral closed triangle; lower molars with the transverse loops long and narrow, the inner reëntrant angles about twice as deep as the outer; first lower molar with anterior loop double, forming a projecting antero-external loop and an internal lateral loop.

Mr. Nelson says of it: "A small wood rat was found living in crevices in the rocks, at an elevation of 12,000 feet, on the north slope of the Sierra Nevada de Colima." This is in the upper fir belt.

At Zapotlan, in the valley below, he obtained five specimens of a form similar to the present but slightly larger and with concolor tails.

Genus **Sitomys.**

Among the small rodents collected are numerous specimens of two mice which in general appearance look almost precisely like the common house mouse (*Mus musculus*), but are still smaller and have shorter tails. They may be roughly separated into two series, according to size. The smaller is a form (or subspecies) of *Sitomys taylori*, which was described by Mr. Oldfield Thomas a few years ago from specimens obtained at San Diego, Duval county, Texas; the larger apparently is an undescribed species, here designated as

Sitomys musculus sp. nov.

Type No. $\frac{33437}{45460}$ ♂ ad. U. S. National Museum (Department of Agriculture collection). From near Colima City, Mexico, March 9, 1892. Collected by E. W. Nelson. (Original number, 2055.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 123; tail vertebræ, 48; hairs, 1; hind foot, 17; ear (in dry skin) from anterior root, 5.5.

General Characters.—In size, color, and external appearance *Sitomys musculus* looks almost exactly like a small common house mouse (*Mus musculus*), except that the tail is shorter. It is smaller than any known species of *Sitomys* except *S. taylori*, from which it differs in being somewhat larger, with longer ears and tail and larger hind feet. It is not quite so dark as typical *S. taylori*, either above or below. The hind feet measure 16 or 17 mm., while those of *S. taylori* measure only 13 or 13.5. Twenty-three specimens have been received from Mr. Nelson from Colima City and Armeria, Colima, and from Plantinar and Zapotlan, Jalisco.

Color.—Upper parts uniform drab-gray, slightly grizzled with black-tipped hairs and faintly tinged with tawny, precisely as in *Mus musculus;* under parts buffy, the basal part of the hairs plumbeous, without sharp line of demarkation; tail above, concolor with back; slightly paler below.

Cranial and Dental Characters.—Skull similar to that of *S. taylori*, but larger; first and second upper molars relatively shorter and thicker; anterior cusp of first upper molar not distinctly (if at all) bi-tuberculate when young; in *S. taylori* it is conspicuously bi-tuberculate.

Genus **Arvicola.**

Mr. Nelson obtained a series of 18 specimens of a new species of *Arvicola* on the Sierra Nevada de Colima, in the state of Jalisco, Mexico, during the latter part of April, 1892. The species belongs to the western section of the subgenus *Mynomes* (characterized by lacking the postero-internal loop of the middle upper molar) and is related to *Arvicola mogollonensis* of Mearns from the pine plateau region of Arizona, but is larger, with the tail and hind feet longer, and is much darker in color. It differs also in cranial characters.

Arvicola phæus sp. nov.

Type No. $\frac{33605}{45640}$ ♀ ad. U. S. National Museum (Department of Agriculture collection). From north slope of the Sierra Nevada de Colima, Jalisco, Mexico (altitude, 10,000 feet), April 21, 1892. Collected by E. W. Nelson. (Original number, 2516.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 155; tail vertebræ, 34; hairs, 4; hind foot, 20½; ear from anterior root, 14 (in dry skin).

Color.—Upper parts dark bistre, grizzled, and thickly interspersed with long black-tipped hairs; under parts plumbeous, more or less washed with dilute tawny-drab; tail indistinctly bicolor, sooty above, paler below.

Cranial and Dental Characters.—Skull resembling that of *Arvicola mogollonensis* in general form and in the vertical expansion of the middle part of the zygomatic arch and the deflection of the short nasals. The incisive foramina are a little more than 1½ times the length of the premaxillary symphesis; the audital bullæ are large and smoothly rounded; the last upper molar has two lateral closed triangles on its outer side, and the first lower molar has 3 lateral closed triangles on the inner and two on the outer side as in typical *Mynomes*, but the middle upper molar has no trace of the postero-lateral loop characteristic of the members of that section from the eastern part of North America.

Genus **Sorex.**

No shrew of the restricted genus *Sorex* has been heretofore known from Mexico, though a single species has been described by Alston from Coban, Guatemala. It is of special interest therefore to record the fact that Mr. Nelson had the good fortune to secure specimens of two species on the north slope of the lofty Sierra de Colima, in Jalisco, neither of which appear to have been described.

One of these, which I have named *Sorex oreopolus*, was found in *Arvicola* runways in grassy places at an altitude of 3,050 meters (10,000 feet); the other, here named *Sorex saussurei*, was captured at the base of a rocky ledge in a sheltered cañon at an altitude of about 2,440 meters (8,000 feet). The latter species may be readily distinguished from the former by its much longer ears and tail, by the color of its under parts, and by cranial proportions. In the relative size of the lateral unicuspidate teeth both of these shrews resemble *Sorex dobsoni* from the Saw Tooth mountains of Idaho, though the height of the teeth is much less.* The first and second upper unicuspids are subequal; the third and fourth likewise are subequal and about half the size of the first and second; the fifth is in the tooth row and distinctly visible from the outside, but is considerably smaller in *saussurei* than in *oreopolus*.

Three specimens of *S. oreopolus* and two of *S. saussurei* were obtained. They may be known from the following descriptions:

---

* See North American Fauna, No. 5, 1891, p. 33.

Sorex oreopolus* sp. nov.

Type No. $\frac{33663}{45698}$ ♂ ad. U. S. National Museum (Department of Agriculture collection). From the Sierra de Colima, Jalisco, Mexico (altitude, 10,000 feet), April 22, 1892. Collected by E. W. Nelson. (Original number, 2517.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 106; tail vertebræ, 36; hairs, 1½; hind foot, 13.

General Characters.—Size rather large; tail short; ears short, scarcely protruding beyond the fur.

Color.—Upper parts uniform sepia-brown, with a 'pepper-and-salt' appearance; under parts uniform drab; tail bicolor, concolor with the upper and lower surfaces of the body, but darker near the tip on the under side.

Cranial and Dental Characters.—Skull smaller than that of *S. oreopolus*, with rostral portion narrower and more compressed; first and second lateral unicuspidate teeth subequal and largest; third and fourth subequal and about half as large as the first and second; fifth rather large, plainly visible to the unaided eye from the outer side, and wholly in the tooth row; considerably longer antero-posteriorly than in *S. saussurei.*

Sorex saussurei† sp. nov.

Type No. $\frac{33667}{45702}$ ♀ ad. U. S. National Museum (Department of Agriculture collection). From the Sierra de Colima, Jalisco, Mexico (altitude 8,000 feet), April 23, 1892. Collected by E. W. Nelson. (Original number, 2538.)

Measurements (in millimeters, taken in flesh by collector).—Total length, 115; tail vertebræ, 48; hind foot, 14.

General Characters.—Size about equalling that of *Sorex oreopolus*, but with tail and ears considerably longer (tail about as long as the body without the head; ears protruding conspicuously beyond the fur).

Color.—Upper parts sepia-brown, slightly darker posteriorly; under parts drab-gray on the throat and breast, clouded with sooty over the belly; tail above concolor with the back, slightly paler on the basal half below.

---

* *’ορεοπόλος*, mountain-haunting.

† Named in honor of Professor Henri De Saussure, of Geneva, Switzerland, who described a number of new mammals from Mexico more than thirty years ago. (Rev. et Mag. Zool., xii, 1860; xiii, 1861; xv, 1863).

Cranial Characters.—Skull somewhat larger than that of *S. oreopolus*, with rostral portion more swollen; first and second lateral unicuspidate teeth subequal and largest; third and fourth subequal and about half the size of the first and second; fifth in the tooth row and distinctly visible from the outside. Though the first and second unicuspids are apparently equal in height, the second is really slightly larger than the first owing to its higher point of origin.

Vol. VII, pp. 175-177 December 22, 1892

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THE OCCURRENCE OF COOPER'S LEMMING MOUSE (*SYNAPTOMYS COOPERI*) IN THE ATLANTIC STATES.*

BY Dr. C. HART MERRIAM.

Synaptomys cooperi is one of the rarest of North American mammals. Both genus and species were described and named 35 years ago by Professor Baird in a peculiarly informal way, in some remarks under the genus *Myodes* in his great work on mammals published in 1857 (Pacific R. R. Reports, vol. viii, 1857, pp. 556–558). The description was based on a very imperfect specimen from an unknown locality, transmitted by Mr. William Cooper, of Hoboken, New Jersey. Of its probable source Professor Baird said: "The animal is undoubtedly North American, probably from the New England states or New York; possibly from Iowa or Minnesota." The type specimen lacked three feet, the tail, and the skin of the head. Another badly damaged skin, lacking both head and skull, accompanied it and may or may not have belonged to the same species.

The next specimen of which we have any record was captured near Brookville, Indiana, in 1866, by Rufus Haymond, and by him transmitted to the Smithsonian, but its identity evidently was not made known until much later, for the species is not mentioned by Haymond in his annotated list of the 'Mammals found at the present time in Franklin County,' Indiana, published in 1869 (First Annual Report, Geol. Surv. Indiana, 1869, 203–208).

---

* Read at a meeting of the Biological Society of Washington, Nov. 5, 1892.

The first published record after Baird's original description seems to have appeared in 1874 in Coues' 'Synopsis of the Muridæ of North America' (Proc. Acad. Nat. Sci., Phila., 1874, 192–194). In this paper Coues mentioned specimens from Indiana, Illinois, Minnesota, Kansas, Oregon, and Alaska, but it is probable, if not absolutely certain, that those from Oregon and Alaska do not pertain to the species under consideration.

The only locality in which *Synaptomys* has been found in anything like abundance is the neighborhood of Brookville, Indiana, where Mr. Edgar R. Quick and Amos W. Butler have obtained a number of specimens. This, moreover, is the easternmost locality from which any positive record has been published. (See Am. Nat., vol. XIX, Feb., 1885, pp. 113–118.)

In April, 1888, Dr. A. K. Fisher, while hunting at Munson Hill, Virginia (only about five miles from the city of Washington), found a number of 'pellets' of the Long-eared owl (*Asio wilsonianus*) under a tree in which one of these owls habitually roosted. In examining these 'pellets,' which were made up almost wholly of the remains of small mammals, I was surprised not only at the large number of individuals and species represented, but also at the discovery among the rest of three more or less perfect skulls of *Synaptomys cooperi*. The total number of skulls found in these pellets was 176, of which 137 were of mice, 26 of shrews, and 13 of birds. The mice and shrews were positively identified as follows:

Arvicola riparius	95
Arvicola pinetorum	24
Mus musculus	15
Synaptomys cooperi	3
Blarina exilipes	23
Blarina brevicauda	3
Total	163

A year and a half afterward a single skull was taken from the stomach of a Barred owl (*Syrnium nebulosum*) killed at Alfred Center, New York, October 11, 1889, and still later another was found in the stomach of a Red-tailed hawk (*Buteo borealis*) killed at Sandy Spring, Maryland, March 24, 1890. These specimens were exhibited at one of the meetings of the Biological Society, but publication was deferred in the hope that a specimen of the animal itself might be obtained.

During the past season I had the good fortune to capture two specimens of *Synaptomys* on the summit of Roan Mountain, North Carolina, in traps set for shrews (*Sorex*) and red-backed mice (*Evotomys*). The first of these, an adult male, was caught August 29, 1892, at the mouth of its runway in a bed of dry moss overrun by mountain bluets (*Houstonia serpyllifolia*) in the edge of a grove of balsam firs (*Abies frazeri*). The second specimen, an adult female, was caught September 8 in a wet sphagnum bog near the spring that supplies the Cloudland Hotel with water. Both were taken at an altitude of 1,830 meters (above 6,000 ft.). Before leaving the mountain these specimens were shown to Mr. Elmer R. Edson, a young man temporarily residing there. Mr. Edson promised to set the 'cyclone' traps left with him, in the hope of securing additional specimens, and has been rewarded by the capture of two adults—one in the same sphagnous bog from which my second specimen came, the other in a grove of balsams on the dry summit. In view of the records here published from North Carolina, Virginia, Maryland, and New York, it seems not unlikely that Baird's type really came from the latter State, or possibly even from New Jersey, the State in which the donor of the specimen, Mr. Cooper, lived.

Persons interested in the capture of rare mammals will do well to keep a sharp lookout for this species in the cooler parts of Pennsylvania and New Jersey.

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PROCEEDINGS.

TWO HUNDRED AND FOURTH MEETING,

January 14, 1893.

Vice-President Dr. Baker in the chair, and thirty-one members present.

Mr. Walter H. Evans was elected an active member.

Dr. Erwin F. Smith presented a paper entitled ADDITIONAL NOTES ON PEACH ROSETTE.*

Mr. D. G. Fairchild presented some NOTES ON APPLE AND PEAR FUSICLADII. The paper was discussed by Messrs. Erwin F. Smith and Waite.

Prof. L. F. Ward spoke upon THE NEW BOTANY.† Prof. Ward's communication was discussed by Dr. Baker.

Drs. Theobald Smith and V. A. Moore followed with a communication upon THE GROWTH OF BACTERIA THROUGH THE PASTEUR-CHAMBERLAND FILTER.‡

TWO HUNDRED AND FIFTH MEETING,

January 28, 1893.

Mr. L. O. Howard in the chair, and thirty-one persons present.

Messrs. D. D. Luke and H. H. Doubleday were elected active members.

Prof. Robert T. Hill presented some NOTES ON THE PALEONTOLOGY OF THE COMANCHE SERIES.§ The paper was discussed by Messrs. Stanton and Ward.

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*Journal of Mycology, vii, pp. 226–232, 1893.

†Science, N. Y., xxi, pp. 43–44, Jan. 27.

‡Zur Prüfung der Pasteur–Chamberland Filter, <Centralblatt f. Bakteriologie und Parasitenkunde, xii, pp. 628–629, 1892.

§Paleontology of the Cretaceous Formations of Texas.—The Invertebrate Paleontology of the Trinity Divisions. <Proc. Biol. Soc. Wash., Vol. viii, pp. 9–40, pls. i–viii, 1893.

Prof. L. F. Ward spoke upon THE FLORA OF THE TRINITY DIVISION ON THE COMANCHE SERIES IN TEXAS, exhibiting specimens and a manuscript and drawings prepared by Prof. W. M. Fontaine.* Prof. Ward's communication was discussed by Messrs. Stanton and Hill.

Mr. C. H. Townsend read a paper entitled SEA-OTTER FISHING IN ALASKA IN RELATION TO THE NATIVES, which was discussed by Messrs. Sheldon Jackson, Dall, Evermann, and Merriam.

TWO HUNDRED AND SIXTH MEETING,

February 11, 1893.

The President in the chair, and thirty-four persons present.

Mr. M. B. Waite presented a communication on THE DESTRUCTION OF LICHENS ON PEAR TREES.†

Mr. Charles Hallock read a paper on THE GEOGRAPHICAL DISTRIBUTION OF THE MUSK-OX.

Mr. C. H. Townsend spoke upon THE PROPAGATION OF THE ATLANTIC COAST OYSTER ON THE PACIFIC COAST. The paper was discussed by Mr. Dall and Mr. Van Deman.

Mr. G. S. Miller exhibited a specimen of A NEW JUMPING MOUSE (*Zapus insignis*).‡

Dr. C. Hart Merriam spoke upon THE FOUR-TOED KANGAROO RATS.

TWO HUNDRED AND SEVENTH MEETING,

February 25, 1893.

The President in the chair, and forty-seven persons present.

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*W. M. Fontaine—Notes on some Fossil Plants from the Trinity Division of the Comanche Series. <Proc. U. S. Nat. Mus., Vol. xvi, pp. 261–285, pls. xxxvi–xliii, 1893.

†Experiments with Fungicides in the removal of Lichens from Pear Trees. <Journal of Mycology, Vol. vii, No. 3, pp. 264–268, pls. xxx–xxxi, 1893.

‡A Jumping Mouse (*Zapus insignis* Miller) new to the United States. <Proc. Biol. Soc. Wash., Vol. viii, pp. 1–8. (Extras issued April 22, 1893.)

Dr. Nordqvist of Finland was present as a guest of the Society.

The Rev. Sheldon Jackson spoke on THE INTRODUCTION OF REINDEER IN ALASKA.* The subject was further discussed by Messrs. Gill, Stejneger, Merriam, Dall, Evermann, Townsend and Nordfeldt.

Mr. M. B. Waite treated of THE VARIATION OF THE FRUIT OF THE PEAR DUE TO DIFFERENCE OF POLLEN.†

Mr. E. M. Hasbrouck read a paper ON THE DEVELOPMENT OF THE APPENDAGES OF THE CEDAR WAX WING.‡

Mr. F. A. Lucas read an article on THE FOOD OF HUMMING BIRDS.§

TWO HUNDRED AND EIGHTH MEETING,

March 11, 1893.

The President in the chair, and forty-eight members present.

Messrs. Outram Bangs of Boston, Mass., Herbert Brown of Tucson, Arizona, and Miss Florence A. Merriam of Locust Grove, N. J., were elected corresponding members.

Dr. Frank Baker read a paper entitled RECENT DISCOVERIES IN THE NERVOUS SYSTEM.‖ The subject was further discussed by Dr. Wm. A. Hammond and Prof. Ward.

Mr. Vernon Bailey spoke upon THE BURROWS OF FIVE-TOED KANGAROO RATS, which called forth remarks from Messrs. Baker, Bailey, Merriam and Coville.

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*Report on Introduction of Domestic Reindeer into Alaska, with Maps and Illustrations. <Misc. Doc. No. 22, 52nd Congress, 2nd Session, 39 pp., Washington, D. C., 1893.

†Effects of Different Kinds of Pollen on the Character of the Fruit (Chap. v of the Pollination of Pear Flowers). <Bull. No. 5, Div. Veg. Path., U. S. Dept. Agric., pp. 55–74, Pls. i–xii, 1894.

‡A presumably new fact relative to the Cedar Wax wing (*Ampelis cedrorum*), with remarks upon the importance of a thorough knowledge of first plumages. <Science, N. Y., xxi, pp. 144, 145, March 17, 1893.

§The Auk, Vol. x, pp. 311–315, Oct. 1893.

‖The New York Medical Journal, lvii, pp. 657–663, 685–692, figs. 1–28, June 17 and 24, 1893.

Mr. E. M. Hasbrouck gave a communication on THE BREEDING OF THE BALD EAGLE NEAR MOUNT VERNON, with an exhibition of eggs. Comments were made by Messrs. John Burroughs and Ward.

TWO HUNDRED AND NINTH MEETING,

March 25, 1893.

The President in the chair, and thirty-five members present.

Dr. William C. Rives of New York was elected a corresponding member.

The President announced the death of Dr. George Vasey, Botanist of the Department of Agriculture, and of Dr. Henry Clay Nelson, United States Army, both members of the Society. On motion by Mr. Walcott, it was voted to appoint some member to present a biographical sketch of Dr. Vasey. The President appointed Mr. Coville.

L. M. McCormick presented a paper on A HYBRID BETWEEN PYRANGA RUBRA AND PYRANGA ERYTHROMELAS.* The paper was discussed by Messrs. Howard and McCormick.

Prof. E. W. Doran read an article on the DEVELOPMENT OF THE INTESTINES OF TADPOLES. Remarks were made upon the subject by Messrs. Dall, Riley, and Reyburn.

Dr. Theobald Smith addressed the Society on THE BACTERIOLOGY OF POTOMAC WATER AND ITS BEARING UPON SANITARY PROBLEMS. This paper gave rise to a long discussion, in which Messrs. Lucas, Dall, Reyburn, Howard, Waite, Riley, and Smith participated.

TWO HUNDRED AND TENTH MEETING,

April 8, 1893.

Dr. C. Hart Merriam in the chair, and twenty-five persons present.

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*The Auk, Vol. x, pp. 302–303, July, 1893.

Mr. F. V. Coville spoke upon the CHARACTERISTICS AND ADAPTATIONS OF A DESERT FLORA.* Remarks followed upon the same subject by Messrs. Smith and Evans.

Mr. C. W. Stiles discussed THE CAUSE OF MEASLY DUCK,† exhibiting microscopic specimens of the disease and the parasite causing it. The subject was further discussed by Messrs. Merriam, Th. Smith, and Gurley.

Dr. R. R. Gurley read a paper on NATURAL SELECTION AS EXEMPLIFIED BY THE CACKLING OF HENS, which was discussed by Messrs. Lucas and Van Deman.

Prof. J. W. Chickering spoke upon THE BOTANICAL LANDSCAPE.‡ His paper was discussed by Messrs. Merriam and Lucas.

TWO HUNDRED AND ELEVENTH MEETING,

April 22, 1893.

The President in the chair, and thirty persons present.

Mr. O. F. Cook presented NOTES ON THE NATURAL HISTORY OF LIBERIA. Mr. Cook's communication was discussed by Dr. Gill.

Mr. J. N. Rose treated of TWO TREES OF ECONOMIC IMPORTANCE FROM MEXICO.§

Dr. V. A. Moore made OBSERVATIONS ON THE DISTRIBUTION AND SPECIFIC CHARACTER OF THE STREPTOCOCCI GROUP OF BACTERIA.‖ The subject was discussed by Dr. Th. Smith.

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*A chapter of botany of the Death Valley Expedition. <Contributions from the U. S. National Herbarium, Vol. ix, pp. 33–55, 1893.

†Notes on Parasites—18: On the Presence of Sarcosporidia in Birds. <Bull. Bur. An. Indust., No 3, U. S. Dept. Agric., pp. 79–88, pls. ii–iii.

‡Science, N. Y., xxiii, pp. 118–119, March 2, 1894.

§A new *Tabebuia* from Mexico and Central America: *Tabebuia Donnell-Smithii.* <Bot. Gaz., Vol. xvii, pp. 418–419. A new *Bumelia* from Mexico (B. Palmeri). <Garden and Forest, vii, p. 195, 1894.

‖Observations on the Morphology, Biology, and Pathogenic Properties of twenty-eight Streptococci found in the investigations of Animal Diseases. <Bull. Bur. An. Industry, No. 3 (U. S. Dept. Agric.), pp. 9–30, 1893.

Dr. Erwin F. Smith considered PEACH YELLOWS AND PLANT NUTRITION.*

TWO HUNDRED AND TWELFTH MEETING,

May 6, 1893.

The President in the chair, and nine persons present.

L. H. Dewey presented a paper entitled GEOGRAPHIC DISTRIBUTION OF GRASSES IN THE UNITED STATES. Mr. Dewey's article was discussed by Messrs. Coville and Palmer.

Dr. Erwin F. Smith spoke ON THE SYMBIOSIS OF STOCK AND GRAFT. Further remarks upon the same subject were made by Messrs. Coville, Riley, and the original speaker.

Dr. Theobald Smith described A NEW SPOROZOON IN THE INTESTINAL VILLI OF THE OX.†

The Communication was discussed by Messrs. E. F. Smith, Riley, and Theobald Smith.

TWO HUNDRED AND THIRTEENTH MEETING,

May 20, 1893.

The President in the chair, and twenty-eight persons present.

Mr. Charles Schuchert was elected an active member.

The following communications were presented.

Dr. V. A. Moore read on THE DISTRIBUTION OF PATHOGENIC BACTERIA IN THE UPPER AIR PASSAGES OF DOMESTICATED ANIMALS.‡

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*Experiments with Fertilizers for the Prevention and Cure of Peach Yellows, 1889–92. <Bull. Div. Veg. Path., No. 4, U. S. Dept. Agric., 197, p. 33, pl., 1893.

†Preliminary Notes on a Sporozoön in the Intestinal Villi of Cattle. <Bull. Bur. An. Indust., No. 3 (U. S. Dept. Agric.) pp. 73–78, pl. i, 1893.

‡Pathogenic and Toxicogenic Bacteria in the Upper Air Passages of Domesticated Animals. <Bul. Bur. An. Ind., No. 3, (U. S. Dept. Agric.) pp. 31–48, 1893.

Prof. C. V. Riley gave some FURTHER NOTES ON YUCCA POLLINATION.* Prof. Riley's communication was discussed by Messrs. Howard and Riley.

Prof. Barton W. Evermann spoke of THE ICHTHYOLOGIC FEATURES OF THE BLACK HILLS.†

Mr. Wm. H. Dall discussed NEW FORMS OF FOSSILS FROM THE OLD MIOCENE OF THE GULF STATES.

Dr. C. Hart Merriam treated of BIOLOGY IN OUR COLLEGES.‡ The paper was discussed by Messrs. Ward, Burgess, and Riley.

TWO HUNDRED AND FOURTEENTH MEETING,

October 21, 1893.

The President in the chair, and thirty persons present.

Mr. Charles Torrey Simpson was elected an active member.

Prof. Lester F. Ward presented a communication entitled WEISMANN'S CONCESSIONS. Prof. Ward's communication was discussed by Messrs. Riley, Dall, Schaeffer, Gill, Coville, and Ward.

Dr. C. Hart Merriam and Vernon Bailey presented some NOTES ON A BIOLOGICAL RECONNOISANCE OF WYOMING.

TWO HUNDRED AND FIFTEENTH MEETING,

November 4, 1893.

The President in the chair, and twenty-three members present.

Mr. W. T. Swingle considered SOME PROBLEMS OF PLANT GEOGRAPHY IN FLORIDA.

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*Further Notes on Yucca Insects and Yucca Pollination. <Insect Life, Vol. v, pp. 300–310, (pl. ii and fig. 38, *a–g*). Also <Proc. Biol. Soc. Wash., Vol. viii, pp. 41–54, pl. ix.

†Proc. Indiana Acad. Sc. for 1892, pp. 73–78 (Abstract).

‡Biology in our Colleges: A Plea for a Broader and more liberal Biology. <Science, N. Y., xxi, pp. 352–355, June 30, 1893.

Dr. C. Hart Merriam spoke on THE FAUNA AND FLORA OF EASTERN WYOMING. Messrs. Rose, Coville, Evermann, and Merriam made informal remarks upon the same subject.

Dr. C. W. Stiles treated of ARTIFICIAL SPECIES OF CESTODES.* This paper was discussed by Messrs. Dall, Merriam, Gill, Fernow and Riley.

TWO HUNDRED AND SIXTEENTH MEETING,

November 18, 1893.

The President in the chair, and thirty-seven persons present.

Mr. Wm. H. Ashmead and Mr. F. C. Pratt were elected active members.

Dr. C. Hart Merriam presented a communication entitled REMARKS ON THE GENUS GEOMYS.† Dr. Merriam's paper was discussed by Messrs. Gill, Ward, Riley, and Merriam.

Mr. Frederick V. Coville spoke upon JUNCUS MARGINATUS AND ITS VARITIES.‡

The question WHAT ARE THE SPECIAL NEEDS OF THE BIOLOGICAL SOCIETY OF WASHINGTON? was discussed by Messrs. Fernow, Stiles, Gill, and Merriam.

TWO HUNDRED AND SEVENTEENTH MEETING,

December 2, 1893.

Dr. Gill in the chair, and twenty-four persons present.

Mr. J. B. Thompson of Washington was elected an active member.

Mr. F. H. Blodgett read NOTES ON THE DEVELOPMENT OF

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*A Revision of the Adult Cestodes of Cattle, Sheep and allied Animals. <Bur. An. Ind. (U. S. Dept. Agric.) Bul. No. 4, pp. 97–101.

†Monographic Revision of the Pocket Gopher's Family, Geomyidæ, (North America Fauna, No. 8) 1895.

‡Proc. Biol. Soc. Wash., pp. 121–128

THE BULB OF THE ADDER'S TONGUE. The subject was discussed by Messrs. Ward, Burgess, and Seaman.

Mr. E. W. Nelson commented on A NEW SPECIES OF LAGOMYS FROM ALASKA.*

Dr. Erwin F. Smith spoke of A BACTERIAL DISEASE OF CUCUMBERS, ETC., WORKING THROUGH THE FIBROVASCULAR BUNDLES AND PROBABLY TRANSMITTED BY INSECTS.† The paper was discussed by Messrs. Seaman and Galloway.

TWO HUNDRED AND EIGHTEENTH MEETING,

December 16, 1893.

Mr. Rathbun in the chair, and thirty persons present.

The evening was given up to short miscellaneous communications.

TWO HUNDRED AND NINETEENTH MEETING,

December 30, 1893.

The President in the chair, and twenty-two members present.

Surg. Gen. Geo. M. Sternberg and Mr. Filibert Roth were elected active members.

The annual reports of the Secretary and Treasurer were read and accepted and officers for the year 1894 were elected as follows:

President, C. V. Riley; *Vice-Presidents*, Frank Baker, B. E. Fernow, Richard Rathbun, C. D. Walcott; *Recording Secretary*, C. W. Stiles; *Corresponding Secretary*, F. A. Lucas; *Treasurer*, F. H. Knowlton; *Councilors*, T. H. Bean, L. O. Howard, T. S. Palmer, Theobald Smith, F. W. True.

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*Description of a New Species of Lagomys from Alaska. <Proc. Biol. Soc. Wash., viii, pp. 117–120.

†A Bacterial Disease of Cucumbers, Cantaloupes and Squashes (Abstract). <Proc. Am. Ass. Adv. Sc. for 1893, p. 259, 1894.

VOL. VIII, PP. 1-8 APRIL 22, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

A JUMPING MOUSE (*ZAPUS INSIGNIS* MILLER), NEW TO THE UNITED STATES.

BY GERRIT S. MILLER, JR.

Zapus insignis, hitherto known only from New Brunswick and Nova Scotia,* is locally common in the eastern United States, and will probably be found to be very generally distributed in the eastern part of the Canadian fauna. The specimens that have thus far come to my notice number forty-two. Of these, the type and two others were collected by E. A. Bangs on the Restigouche river, New Brunswick, in September, 1880; one was taken in Northumberland county, N. B., in June, 1892, by Gerrit S. Miller, and two (Nos. 4061 and 5785, collection of Dr. C. Hart Merriam) were collected at Godbout, P. Q., Canada, by Napoleon A. Comeau. The remainder were taken in the United States, as follows: Eleven by Mr. Frank Bolles at Chocorua, N. H., in September, 1892; two by Mr. C. F. Batchelder at Keene, Essex county, N. Y., in August, 1890; four at Elizabethtown, Essex county, N. Y., and nineteen at Peterboro, Madison county, N. Y., by the writer during the spring and summer of 1892.

With the possible exception of Mr. Comeau's specimens, of whose history I am ignorant, these were all taken in the woods, and generally close to water. The banks of running streams are especially attractive to these animals; many that I have caught actually sprang into the water in their death struggles. In such places they may be taken without difficulty in traps baited with rolled oatmeal, after these have been left in one place long enough to thin out the white-footed mice and short-tailed shrews. In my experience *Zapus insignis* is wholly a dweller in deep woods, never venturing out into grass fields and damp pastures, such as *Z. hudsonius* delights in, and avoiding thinly wooded places in general. *Zapus hudsonius*, on the other hand, seldom penetrates far into the woods, and the two species are not often found together, though I have several times taken both in the same traps on successive days, near the edge of some meadow or clearing. Dawson states that both kinds of jumping mice are found in grain fields near Halifax and Pictou, N. S. He adds, however, that the smaller species (*i. e.*, *Z. hudsonius*) is in such places much the more common and easily observed.

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*See American Naturalist, xxv, August, 1891, 472.

The original description of this species, based on three specimens somewhat faded by grease and age, was necessarily incomplete, and in some respects misleading. Hence it seems advisable to redescribe the animal, that there may be no future difficulty in recognizing it.

Zapus insignis Miller.

Meriones labradorius Dawson. Edinburgh New Phil. Journ., iii, 1856, 2.

Zapus insignis Miller. American Naturalist, xxv, August, 1891, 472.

Sp. Ch. Larger than *Zapus hudsonius* Zimmerman, with longer ears and paler, more fulvous coloration; tail when uninjured always tipped with white; teeth, i. $\frac{1-1}{1-1}$, pm. $\frac{0-0}{0-0}$, m. $\frac{3-3}{3-3}$ $= 16$.

Adult male (No. $\frac{1656}{1452}$, collection of G. S. Miller, Jr., Peterboro, N. Y., August 22, 1892); length, 250; tail vertebræ, 154; hind foot, 31.6; ear from notch, 18.6. Tip of tail for 23 mm., dorsum of manus and pes, and entire ventral surface pure white to base of hairs; sides buff-yellow, tinged with clay color, except on cheeks, fore neck, and a narrow line bordering white of belly, where the yellow is noticeably purer; the fur plumbeous gray at base and a trifle sprinkled with blackish bristly hairs. These blackish hairs predominate on the back, where they form a sharply defined dorsal stripe slightly mixed with the color of the sides, broadest just back of the shoulders, tapering gradually to base of tail, and becoming indistinct on the head after passing between the ears. Ears externally concolor with back, internally buff-yellow; muzzle grayish brown; whiskers mixed brownish and whitish, the longest hairs reaching beyond shoulders; tail thinly haired, so that the annulation shows distinctly, sharply bicolor, dark brown, except ventrally and at tip.

Among the specimens of *Zapus insignis* that I have examined I find but little individual variation in color. That which occurs seems to be due chiefly to season, spring specimens having the sides brighter fulvous than those taken in the autumn and late summer. The dorsal stripe is darker and more sharply defined in some specimens than in others, the variation being caused by the relative quantities of blackish and fulvous hairs. In specimens with perfect tails the extent of the white tip varies from 30 mm. down to a mere trace; but the latter condition is rare, occurring only twice in the series before me, most tails showing from 10 mm. to 20 mm. of white.

The four males taken at Elizabethtown, N. Y., in April are brighter colored than the type and have apparently longer ears. These discrepancies are probably due entirely to the different condition of the specimens. Skins taken at Peterboro, N. Y., late in August and early in September are nearly as dull as the three from Restigouche, while the June specimen from Northumberland county, N. B., less than one hundred miles from the type locality, is fully as bright as any that I have seen. This specimen (No. 1438) is alcoholic, but the comparison was made a few days after its capture. The ear of No. 1438 is somewhat longer than that of an alcoholic specimen (No. 2000) from Peterboro, while the ears of Mr. Batchelder's specimens from Keene, N. Y., measure dry only a trifle more than the ears of the Restigouche skins.

On comparing thirty-eight skins of *Zapus insignis* with about one hundred specimens of *Z. hudsonius* from various parts of New Brunswick and the eastern United States, the paler, more fulvous coloration of the former at once strikes the eye. The ground color of the lateral stripe in *hudsonius* is more strongly tinged with clay color and is much more plentifully interspersed with black bristly hairs. There is no tendency in *hudsonius* to form the clear yellow area on the sides of the head and fore neck so conspicuous in *Z. insignis*. In the former, however, the clear yellow line separating the lateral stripe from the white of the belly is apt to be more strongly defined and of a somewhat darker shade. *Z. insignis* is always pure white beneath, never showing a trace of the buffy suffusion commonly seen in *Z. hudsonius.* Yellow is the prevailing color on the head of *insignis*, while in *hudsonius* the black hairs are the more numerous on the head and face. The gray muzzle is much paler in *insignis* than in *hudsonius.* The ears of the two species differ notably in color as well as in size, those of *Z. hudsonius* being more thickly haired and blackish throughout, except for a sprinkling of yellowish hairs on the outside and a narrow, pale—sometimes white—border, while in *Z. insignis* the ears are lined with yellow and clothed outside with dusky and yellow hairs in about equal proportions, the latter forming a pale though never white edging.

Two young examples of *Z. hudsonius* (♂ *juv.* No. $\frac{1635}{1432}$ and ♂ *juv.* No. $\frac{1636}{1433}$, Peterboro, N. Y., August 1, 1892), otherwise perfectly typical, have 8 mm. of the distal end of the tail white. These are the only specimens of the species in which I have seen the slightest indication of this character, but it is to be expected since most of our small mammals occasionally have white-tipped tails. I have repeatedly noticed it in two races of *Sitomys americanus*; also occasionally in *Mus musculus*, *Arvicola riparius*, and *Blarina brevicauda.* It is thus especially noteworthy that in *Zapus insignis* this character, elsewhere merely accidental, should have become so fixed as to be practically diagnostic.

The skull of *Zapus insignis* closely resembles that of *Z. hudsonius*, but is throughout slightly broader and heavier, with a less highly arched brain case. Except for its somewhat larger size, the mandible shows no points of difference.

The teeth are all somewhat heavier than in *Z. hudsonius* and the crown of the middle upper molar appears in some specimens slightly longer proportionally.

In the original description of *Z. insignis* it was suggested that the absence of the premolar might be due to the age of the specimens at hand and consequent shedding of the tooth. That this view is incorrect is conclusively shown by the material now available. Specimens of *Z. hudsonius* with teeth excessively worn still retain the premolar, while in *Z. insignis* I have never found a trace of this tooth, even in individuals so young that the posterior molar has not cut through the gums. I have seen but one specimen of *Z. hudsonius* in which the premolar is absent. This I suppose to be the skull from Pennsylvania referred to, on the authority of Mr. F. W. True, in the original description of *Z. insignis*. The specimen (No. $\frac{1684}{558}$, United States National Museum, Upper Darby, Pa.) is in a very fragmentary condition, but one tooth row remaining *in situ*, and the maxilla being broken off close to the roots of the first molar. Under these circumstances no weight can be placed on the fact that the premolar is not to be found.

Measurements of Forty Specimens of Zapus insignis.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Hind foot.	Ear from notch.	Measured.
Skin.	Skull.								
464	387	Restigouche river, N. B.	Sept. 10, '80	♀	225	126	30	12.8	Dry.*
1	......	“ “	“ 8, '80	♂	224	141	30.8	13	“ †
4	......	“ “	“ 10, '80	♂	235	140	30.4	14	“
1438	......	Northumberland Co., N. B.	June 2, '92	♂	218	125	30	16.4	In alcohol.
4061	......	Godbout, P. Q., Canada.	Aug. 27, '85	♀	240	158	32	.....	“ ‡
5785	......	“ “	June 10, '85	♂	250	160	32.5	.....	“
2	......	Keene, Essex Co., N. Y.	Aug. 8, '90	♂	.....	.....	29.6	14.6	Dry.§
8	......	“ “	“ 10, '90	♂	.....	.....	31	14.2	“
1376	1192	Elizabethtown, Essex Co., N.Y.	April 3, '92	♂	242	147	30.5	18	Fresh.
1377	1193	“ “	“ 9, '92	♂	238	146	30.8	18	“
1378	1194	“ “	“ 10, '92	♂	....	157	32.4	18	“
1379	1195	“ “	“ 13, '92	♂	253	157.5	32	17.5	“
1647	1443	Peterboro, Madison Co., N.Y.	Aug. 17, '92	♂	235	146	31.4	17	“
1656	1452	“ “	“ 22, '92	♂	250	157	31.6	18.6	“
1657	1453	“ “	“ 23, '92	♂	253	158	32	17.8	“
1658	1454	“ “	“ 23, '92	♂	240	146	31	17.8	“
1659	1455	“ “	“ 23, '92	♂	243	150	31	17.6	“
1660	1456	“ “	“ 23, '92	♀	234	146	30.8	17	“
1664	1460	“ “	“ 25, '92	♀	239	145	29.8	17.2	“
1665	1461	“ “	“ 25, '92	♀	235	144	32	17	“
1666	1462	“ “	“ 25, '92	♂	225	148	32.2	18	“
1667	1463	“ “	“ 25, '92	♂	235	142	30	17	“
1673	1468	“ “	“ 29, '92	♀	240	148	30	16.6	“
1674	1469	“ “	“ 29, '92	♀	237	142	30	17.2	“
1675	1470	“ “	“ 29, '92	♀	228	133	30	17	“
1676	1471	“ “	“ 29, '92	♂	245	152	31.6	18	“
1677	1472	“ “	“ 29, '92	♂	230	142	30	17	“
1682	1477	“ “	Sept. 9, '92	♀	231	143	29	16.6	“
1713	1504	“ “	“ 23, '92	♂	235	141	31	17.4	“
2000	......	“ “	Oct. 18, '92	♀	225	138	30	15.8	In alcohol.
1972	......	Chocorua, Carroll Co., N. H.	Sept., 1892	....	.....	144	29.4	15	Dry.
1973	......	“ “	“ “	....	...	147	31	15.6	“
1974	......	“ “	“ “	....	.....	134	29.8	14	“
1975	......	“ “	“ “	....	.....	138	29.8	15	“
1976	......	“ “	“ “	....	.....	138	30	16	“
1977	......	“ “	“ “	....	.....	138	28	15	“
1978	......	“ “	“ “	....	.....	157	31	16	“
1979	......	“ “	“ “	....	....	146	30.4	15.4	“
1980	......	“ “	“ “	....	.....	143	30.4	16.4	“
1981	......	“ “	“ “	....	.....	150	30.4	16	“

* Type.

† Collection of E. A. and O. Bangs.

‡ Collection of Dr. C. Hart Merriam.

§ Collection of Chas. F. Batchelder.

Measurements of Forty Specimens of Zapus hudsonius.

Number.		Locality.	Date.	Sex.	Total length.	Head and body.	Tail vertebræ.	Hind foot.	Ear from notch.
Skin.	Skull.								
787	......	Oak Bay, N. B......	Sept. 19, '91	....	241	.....	148	33	13 *
1414	......	" "	Oct. 7, '91	....	190	.....	114	28	11
1836	1614	" "	....	♀	215	.....	134	31.4	12.4
1840	1618	" "	....	♀	203	.....	132	31	11
1841	1619	" "	....	♂	215	.....	138	30.6	11.6
1842	1620	" "	....	♂	215	.....	135	31	11
1846	1624	" "	....	♂	225	.....	140	32	11
583	517	Peterboro, Madison Co., N. Y.	July 17, '91	♂	217	.....	134	30	12
584	518	" "	" 17, '91	♀	198	.....	143	31.2	12.8
585	519	" "	" 17, '91	♀	217	.....	132	30	11.8
586	520	" "	" 17, '91	♀	214	.....	135	31.6	13
587	521	" "	" 17, '91	♀	221	.....	142	31.5	12.8
588	522	" "	" 17, '91	♀	216	.....	139	30	13.4
620	538	" "	" 20, '91	♀	208	.....	128	29.6	12.2
622	539	" "	" 21, '91	♂	185	.....	116	29.5	10.5
623	540	" "	" 21, '91	♀	217	.....	127	28.8	13
624	541	" "	" 21, '91	♀	215	.....	137	30.4	12.4
625	542	" "	" 21, '91	♀	231	.....	152	31.4	13
626	543	" "	" 21, '91	♀	214	.....	129	30	12
627	544	" "	" 21, '91	♀	219	.....	132	30.6	11.4
628	545	" "	" 21, '91	♂	194	.....	122	27.5	12
630	546	" "	" 21, '91	♂	209	.....	128	29	11.4
631	547	" "	" 21, '91	♂	200	.....	122	28	11
1622	1419	" "	" 30, '92	♂	215	.....	124	31	14.6
1635	1432	" "	Aug. 1, '92	♂	205	.....	131	30.4	13
1636	1433	" "	" 1, '92	♂	200	.....	128	30	12.8
1646	1442	" "	" 9, '92	♀	202	.....	120	29	13.8
1650	1446	" "	" 18, '92	♀	203	.....	125	28	13
1663	1459	" "	" 25, '92	♂	203	.....	124	28	13
1669	1464	" "	" 26, '92	♀	198	.....	121	28	12.8
1679	1474	" "	Sept. 7, '92	♂	198	.....	118	29.6	13.8
1703	1495	" "	" 17, '92	♂	229	.....	129	30.8	14.4
1704	1496	" "	" 17, '92	♂	205	.....	120	29.6	14
1705	......	" "	" 17, '92	♂	208	.....	125	30	14
1427	1239	Wareham, Plymouth Co., Mass.	May 28, '92	♂	.....	88	128	29	10 †
1944	1718	" "	July 13, '92	♀	.....	65	123.5	28	10.5
1945	1719	" "	Aug. 18, '92	♀	.....	89	131	29.5	8.5
1946	1720	" "	July 7, '92	♂	.....	86	148	29.5	12.5
1947	1721	" "	" 13, '92	♂	.....	63.5	117	27	10
1948	1722	" "	Aug. 12, '92	♂	.....	83	137	30.5	14

*Collected by H. H. McAdam. †Collected by Outram Bangs.

Cranial Measurements of Six Specimens of Zapus insignis.

Number	387 464	1*	1194 1378	1195 1379	1452 1656	1469 1674
Sex	♀	♂	♂	♂	♂	♀
Basilar length	18.5	19	19	19.8	20	19.8
Basilar length of Hensel	16.8	16.8	17.4	17.8	17.8	17.4
Zygomatic breadth	12.4	12.2	12.8	13	13	12.8
Mastoid breadth	10.2	10.3	10.6	11	11	10.6
Interorbital constriction	4.8	5	5	5	5	5
Greatest length of nasals	9.2	9	9.8	10	10.6	9.4
Incisor to molar	6	6.5	6	6	6.4	6
Incisor to post-palatal notch	8.8	8.8	9	9	9	9
Foramen magnum to post-palatal notch	7.8	7.8	8.4	8.8	8.8	8.6
Upper molar series along crowns.	3.7	3.7	4	4	3.8	3.8
Basioccipital to middle of parietal	7.6	8.5	7.4	7.8	7.4	8
Fronto-palatal depth at middle of molar series	12	6	6	6	6.4	6.2
Greatest length of mandible	12	11.8	12	12.4	12.8	12.2
Lower molar series along crowns.	4	4	4	4	4	4

*Collection of E. A. and O. Bangs.

Cranial Measurements of Six Specimens of Zapus hudsonius.

Number	519 585	540 623	541 624	542 625	543 626	547 631
Sex	♀	♀	♀	♀	♀	♂
Basilar length	18.2	18.2	17.4	17	17	17
Basilar length of Hensel	16.2	16.4	15.4	15	16.2	15.8
Zygomatic breadth	11.2	11.8	11.2	10.8	11	11.2
Mastoid breadth	10	10	10	9.8	10	10
Interorbital constriction	4	4.2	4	4.2	4.2	4.4
Greatest length of nasals	8.6	9.2	8.6	8.2	8.6	8.6
Incisor to molar	6	5.4	6	5.2	6	5.2
Incisor to post-palatal notch	8.4	8.2	8.4	7.8	8.2	8
Foramen magnum to post-palatal notch	7.4	8.2	7.4	8	8	8
Upper molar series along crowns.	3	3.2	3	3	3	3
Basioccipital to middle of parietal	8.2	8	8	8.2	7.4	8
Fronto-parietal depth at middle of molar series	5.6	5.8	6	5.8	6	5.8
Greatest length of mandible	11.4	11.8	11	11.4	11	10.4
Length of lower molar series along crowns	3.4	3.2	3.2	3.4	3.2	3.4

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS—THE INVERTEBRATE PALEONTOLOGY OF THE TRINITY DIVISION.*

BY ROBERT T. HILL.†

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I.—*STRATIGRAPHIC DIVISIONS AND NOMENCLATURE OF THE COMANCHE SERIES.*

It has heretofore been impossible to present faunal studies of the paleontology of the various horizons of the Comanche Series, owing to the fact that the fundamental problems concerning the sequence and relative importance of its subdivisions had not been presented until lately, although the identity of the series, as a whole, was made known in 1886. Prior to that time most of its fossils had been described by Shumard, Roemer, and others, but it was supposed that the species all came from beds which were in some manner equivalents of the upper Cretaceous or the well known Meek and Hayden section. Since the writer ascertained that the Comanche Series was a distinct and lower Cretaceous formation he has spent several years in studying the subdivisions and their extent, in ascertaining the stratigraphic position of the fossils or faunas already described, and in arriving at a rational system of nomenclature.* These steps were necessary before the homotaxy of the series could be discussed.

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* Presented at a meeting of the Biological Society of Washington, held January 28, 1893, and published by permission of the Director of the United States Geological Survey.

† The writer desires to express his indebtedness to the many friends whose advice has assisted him in the preparation of this paper: to Messrs. T. W. Stanton, W. H. Dall, Alpheus Hyatt, and F. H. Knowlton, of the United States Geological Survey, for aid in the determination of doubtful genera, and to Mr. J. L. Ridgway, artist, and Mr. C. W. Eddy, of Ware, Massachusetts, photo-engraver.

In early papers by the writer,† pending more minute study of details, the Comanche Series was broadly divided into two divisions or convenient groups of strata, as follows:

(1) An Upper or Washita Division, so named because of its prevalent occurrence in the vicinity of Old Fort Washita, Indian Territory, whence some of the species, which I ascertained were peculiar to this division, were originally described by Professor Jules Marcou and the brothers Shumard. (2) A Lower, or Fredericksburg Division,‡ so named because many of its characteristic species were those described originally from the vicinity of Fredericksburg, Texas, by Dr. Ferdinand Roemer.§

In 1887, while studying the Cretaceous formations of Arkansas, the writer discovered that the beds of the Fredericksburg Division, so called, consisted of two well-defined groups of strata entirely distinct from each other in paleontologic characters, and that it could be appropriately made into two divisions. For the upper of these, which is composed of the Caprina limestone and the "Comanche Peak Group" of Shumard in part, the name Fredericksburg was retained, and to the lower the name Trinity Division was given, thus dividing the Comanche Series, more in accord with its natural grouping, into three great divisions, instead of two, as originally proposed.

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* The Comanche Series of the Arkansas-Texas Region, by Robt. T. Hill: Bull. Geol. Soc. of America, vol. II, pp. 503–528.

† The Topography and Geology of the Cross-Timbers and Surrounding Regions in Northern Texas: Am. Journ. Sci., vol. XXXII, April, 1887.

‡ It has been alleged (Third Annual Report Texas Geological Survey, p. 272, and American Geologist, January, 1893), that the term Fredericksburg Division was originated by Dr. Ferd. Roemer. Inasmuch as Dr. Roemer never recognized the existence of the Comanche Series, it is impossible to suppose that he named its divisions, and from none of his writings can such an inference be made.

§ The evolution of knowledge concerning the Cretaceous formations of Texas prior to the writer's publications is set forth in Bulletin 45 of the U. S. Geological Survey.

Since the publication of his Arkansas report* the writer has devoted several years to the study of the Trinity Division in Texas and Indian Territory, and has more fully differentiated its beds from those of the overlying Fredericksburg Division, and, furthermore, ascertained that it constitutes a paleontologic and stratigraphic division of the utmost importance in the interpretation of the North American Cretaceous.

In the same report upon the Arkansas Cretaceous a preliminary description of the Trinity Division was made, separating it into a lower or arenaceous terrane, and an upper or calcareous terrane, for which, in a final paper† upon the stratigraphic subdivisions of the Comanche Series, read before the Geological Society of America at its Washington meeting, December, 1890, the names of the Trinity sands and Glen Rose beds were respectively proposed and the following general arrangement of the series given:

C. The Washita or Indian Territory Division.
    10. The Denison beds.
    9. The Fort Worth limestone.
    8. The Duck Creek chalk.
    7. The Kiamitia clays or *Schloenbachia* beds.
B. The Fredericksburg or Comanche Peak Division.
    6. The *Caprina* and Goodland limestone.
    5. The Comanche Peak chalk.
    4. The *Gryphæa* rock and Walnut clays.
    3. The Paluxy sands.
A. The Trinity Division.
    2. The Glen Rose, or alternating, beds.
    1. The Trinity, or basal, sands.

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* The Neozoic Geology of Southwestern Arkansas, vol. II of the Annual Report, Geological Survey of Arkansas, 1888.

† Loc. cit.

II.—POSITION AND CHARACTERISTICS OF THE TRINITY DIVISION.

Fuller details concerning the extent and occurrence of the Trinity Division have been largely set forth during the past year in a publication by the writer,* and much of its stratigraphic details and some of the final maps as made by him and his assistants, Messrs. J. A. Taff, J. S. Stone, W. T. Davidson, and N. F. Drake, have been printed still later.†

The details of the formation can be appreciated by referring to the published descriptions of three typical sections, made at widely separated intervals, showing the increasing thickness of the beds to the southward.

The first of these, made by the writer while employed upon the work of the Arkansas State survey, is described in the report upon the Neozoic geology of southwestern Arkansas.‡

The second represents the beds as they occur in the vicinity of the Paluxy and Brazos rivers, in north central Texas, and was made by the writer and his assistants, Messrs. J. S. Stone and W. T. Davidson, and published in the report "On the Occurrence of Underground Water," § and later in the Third Annual Report of the Geological Survey of Texas.‖ In this region the beds of the Trinity Division attain an established thickness of about 475 feet.

The third and southernmost section was made along the banks of the Colorado river between Austin and the Paleozoic contact in Burnet county by the writer and his assistants, Messrs. J. A. Taff and N. F. Drake. The rocks of the Trinity Division attain unusual development in this region and are very satisfactorily exposed. A profile ¶ illustrating this section is published in the report upon the "Occurrence of Artesian Water," and much of the detail of the section given in the Third Annual Report of the Texas Geological Survey.* The thickness of the rocks of the Trinity Division in this region is about 500 feet. The beds have not been systematically studied in their extent south of the Colorado river.

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* "On the Occurrence of Artesian and Other Underground Waters in Texas, New Mexico, and Indian Territory West of the Ninety-seventh Meridian" (pp. 41–166 of "Final Reports of the Artesian and Underflow Investigation, etc., to the Secretary of Agriculture." 52d Congress, 1st Session, Ex. Doc. 41, part 3, Washington, D. C., May, 1892).

† Report on the Cretaceous Area North of the Colorado River, by J. A. Taff. Austin, Texas, September, 1892.

‡ Op. cit., pp. 116–126.

§ Op. cit., pp. 111–112.

‖ Op. cit., pp. 307, 310, 311.

¶ Loc. cit., pp. 90–91.

From study of these sections it is concluded that the beds, as a whole, indicate a progressive and continuous series of sediments, representing subsidence from land through littoral to offshore conditions, followed by renewed shallowing at its close. It consists of sands and conglomerates at its base, and grades upward into magnesian and chalky limestones. No sharp lines of demarcation can be drawn between the sands and limestones, so imperceptibly do they merge into each other.

The Basement Beds or Trinity Sands proper.—These consist mostly of unconsolidated fine conglomerate and sands of the nature locally known as pack sands, and contain, besides logs of silicified wood, occasional masses of firm, lustrous lignite of depressed oval cross-section, like those found in the Potomac formation near Muirkirk, Maryland. Large bones of vertebrates have also occasionally been found, notably near Millsap, Texas, Travis Peak post-office, and at Gypsum Bluffs, Arkansas, which are supposed to be the remains of Dinosaurs. It was owing to the occurrence of these bones that in an early paper these sands were at first termed the Dinosaur sands by the writer.†

The Glen Rose Beds.—Indurated layers of impure calcareous and yellow material succeed the sands, and become more calcareous and magnesian toward the top of the sections, but without any defined breaks in the sedimentation. In the medial and upper portions of the sections the magnesian and limestone strata assume great thickness and purity, and are separated by alternations of laminated, calcareous, and magnesian clays, as beautifully shown in the bluffs of Mount Bonnel, on the Colorado river, northwest of Austin.‡

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* Loc. cit., pp. 265–300; also First Annual Report of Texas Geological Survey for 1889, 1890, p. lxxxv.

† Am. Journ. Sci., vol. xxxiii, April, 1887, p. 298.

‡ Photographs of the scenery and structure of the Cretaceous formations of Texas, made by the writer for the Texas State Geological Survey, can be procured from the Committee on Photographs of the Geological Society of America.

Molluscan and other invertebrate remains appear coincident with the calcareous beds, accompanied in some instances by plant and vertebrate remains, as at the plant beds three miles west of Glen Rose, Somervell county, Texas.

Aggregations of Species in Great Beds.—In various parts of the Glen Rose beds there are strata composed of shells of one predominant species; while in other cases there is an agglutination of shell fragments of many species in masses similar to the recent formation on the coast of Florida known as Coquina.

Coquina Beds.—These usually appear at the base of the Glen Rose beds or at the first appearance of marine mollusks in the series. In Arkansas, owing to greater alteration through calcification, they consist of much more indurated limestone material than in Texas. The massive beds are composed almost exclusively of small shells of many species, and usually have a dark-yellow color upon weathering. They outcrop at many places along the old military road between Antoine and Ultima Thule. Shell beds are especially well developed near Travis Peak post-office, near the Colorado river, where the Coquina beds are pure white in color and the shell fragments more siliceous and comminuted than in Arkansas.

The Oyster Agglomerate.—Near the base of the Travis Peak section is a stratum some four feet in thickness, composed exclusively of a fossil *Ostrea*, so poorly preserved that the specific nature cannot be ascertained; but which resembles *O. franklini* Coquand. A similar bed of *Ostrea franklini* occurs in the west bluff of the Little Missouri, three miles west of Murfreesboro, Arkansas.

The Vicarya Beds.—At Post Mountain, west of the town of Burnet, there is the remnant of a vast bed of agglomerate, composed entirely of the shells herein described as *Vicarya lujani* de Verneuil, cemented by a hydrocarbon matrix, probably grahamite. This bed is some ten feet in thickness, and is evidently near the base of the Glen Rose beds.

The Orbitulites Chalk.—Near the base of the Bluffs of the Colorado, about the middle of the Glen Rose beds (Upper subdivision) is a stratum of ten feet or more in thickness, composed entirely of a massive white chalk, studded with the minute shells of the foraminifera *Patellina* (*Orbitulites*) *texana* Roemer. This chalk extends southward into Hays, Comal, and adjacent counties.

The Requienia ("Caprotina") Limestone.—At Granbury and in southwestern Parker county there is a vast agglomerate composed entirely of the shells and casts of *Requienia texana* Roemer, to which Dr. B. F. Shumard gave the name "Caprotina limestone." This occurs well up in the Glen Rose beds, about one hundred feet from their top. There is a similar bed in the ravine near the east foot of Mount Bonnel, west of Austin. As shown by the writer,* there is another horizon of Caprotina limestone higher in the Comanche Series.

The Nerinæa Flags.—The summit of the Glen Rose beds, as seen in Mount Bonnel, consists of alternations of dimension layers of firm crystalline limestone and pseudo-oolitic marls. Some of these dimension layers in the peak of Mount Bonnel are composed almost exclusively of calcified forms of *Nerinæas.*

III.—FOSSILS OF THE TRINITY DIVISION.

The beds contain many plant, vertebrate, and invertebrate remains, which occur either separately or in association, as at one locality in the bed and banks of Paluxy creek, three miles west of Glen Rose, Texas. The more sandy basement beds, or Trinity sands, are, as a rule, deficient in organic remains, with the exception of silicified wood and lignite, although occasional vertebrates and invertebrates are found.

The lower beds of the Glen Rose subdivision abound in invertebrate remains, most of which, however, are but badly preserved casts. The Glen Rose beds also contain occasional plants and vertebrates, especially in their lower portion, where they grade into the underlying sands.

The upper beds of the Glen Rose Division are less abundant in fossil remains, and these are very poorly preserved as casts. The plants of the basement Glen Rose beds have been collected by Professor Lester F. Ward, of the United States Geological Survey, and studied by Professor W. M. Fontaine, of the University of Virginia. They are now in course of publication in the Proceedings of the United States National Museum.† The small but interesting collections of vertebrate remains, with the exception of a lepidotoid fish in the hands of Professor Cope, have not been studied. In this paper will be presented a preliminary study of its invertebrate fauna.

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* First Annual Report of the Geological Survey of Texas, 1889, Austin, 1890, p. 133.

† Proc. U. S. Nat. Mus., vol. xv, pp. —, pls. xxxv–lxiii.

The following is a list of the fossils collected or observed by the writer from all the beds of the Trinity Division in Arkansas and Texas:

Foraminifera:
- *Patellina texana* (Roemer).

Echinodermata:
- *Epiaster* (?) sp. indet.

Vermes:
- *Serpula paluxiensis* sp. nov.

Molluscoidea:
- Genus indeterminate.

Mollusca:
- *Anomia texana* sp. nov.
- *Ostrea franklini* Coquand.
- *Ostrea franklini ragsdalei* var. nov
- *Pecten stantoni* sp. nov.
- *Modiola branneri* sp. nov.
- *Leda harveyi* sp. nov.
- *Cucullæa gratiota* Hill.
- *Cucullæa comanchensis* sp. nov.
- *Cucullæa terminalis* Conrad.
- *Barbatia parva-missouriensis* Hill.
- *Trigonia stolleyi* sp. nov.
- *Trigonia crenulata* Roemer.
- *Chione* (?) *decepta* sp. nov.
- *Eriphyla pikensis* Hill.
- *Requienia texana* (?) (Roemer).
- *Monopleura marcida* White.
- *M. pinguiscula* White.
- *Corbicula arkansaensis* Hill.
- *Cardium* (?) *sevierense* Hill.
- *Protocardia* sp. indet.
- *Pholadomya knowltoni* sp. nov.
- *Pholadomya lerchi* sp. nov.
- *Pleuromya* (?) *henselli* sp. nov.
- *Isocardia* (?) *medialis* Conrad.
- *Natica* (?) *texana* Conrad.

Viviparus natica (?) *cossatotensis* Hill.
Cylindrites (?) sp. indet.
Buccinopsis (?) *parryi* Conrad.
Tylostoma pedernalis (Roemer).
Vicarya branneri sp. nov.
Nerinæa austinensis Roemer.
Neritina sp. indet.
Neumayria walcotti Hill.
Acanthoceras (?) *justinæ* sp. nov.

Arthropoda:
Cypridea texana sp. nov.

Vertebrata:
Lepidotus.
Crocodila.
Dinosauriia.
Chelonia.

Plantæ:
Many species, now in course of publication by Professors Ward and Fontaine, together with undetermined species resembling *Araucarites*, figured on plate 1.

IV.—AGE AND SIGNIFICANCE OF THE TRINITY DIVISION.

With the exception of the genera *Requienia* and *Monopleura*, the above list contains none of the hitherto familiar types of fossils found in the overlying Fredericksburg and Washita Divisions, such as the characteristic *Echinodermata*, *Radiolites* (alleged *Hippurites*), *Gryphæas* of the *Pitcheri* group, *Exogyras*, or *Schloenbachiate Ammonitidæ*, but possesses a molluscan fauna peculiarly its own, so far as America is concerned, which, accompanied by a well-preserved flora and vertebrate fauna, affords the first satisfactory and complete data for an age classification of the subdivisions of the North American Lower Cretaceous formation, and will enable us to more thoroughly interpret the succeeding divisions. This association of vertebrates, plants, and marine mollusca is a most important fact in the correct determination of the age of these beds, and they all apparently agree in conclusions.

Concerning the interpretation of the foregoing fossils, the following facts may be stated: The plants, as determined by Professors Ward and Fontaine, originally in the Potomac region,* were long since referred by them to the Wealden, before they were known to occur in the magnificent Texas stratigraphic series.

The vertebrates have never been systematically studied nor collected, but the genera found all occur in the Lower Cretaceous of Europe.

Of the invertebrates the ostracoid crustacean *Cypridea* of the Glen Rose lower beds is, in Europe as in Texas, a prominent feature of the Wealden (Lower Neocomian) beds.

The foraminifer *Patellina* (*Orbitulites*) *texana* Roemer is indistinguishable from the *Orbitulites*, which characterizes the Upper Neocomian of France, and occurs there under lithologic conditions similar to those in Texas.

Of the Pelecypod mollusca proper the *Anomia* is indistinguishable from the *Anomias* of other ages.

The only Ostrea (*O. franklini* Coquand) seem identical with the figures of a form which has been described under many specific names from the Upper Jurassic, and Lower Cretaceous of Europe.

Pecten stantoni belongs to a group of the *Pectinidæ*, which has great specific development in the Neocomian of France, Spain, and Portugal.

Modiola, *Leda*, *Cucullæa*, *Protocardia*, *Corbicula*, *Pholadomya*, and the doubtful form called *Isocardia* have a wide range in the geologic column, but the forms found in the Trinity Division have a general varietal resemblance to those of the Neocomian.

The only well-defined species of *Trigonia* (*T. stolleyi* sp. nov.) belongs to the scabrate forms peculiar to the Cretaceous and later epochs. This is an important fact against the possible Jurassic age of the beds.

The aberrant genera, *Requienia* and *Monopleura*, which abound in the Glen Rose beds, are both characteristic Lower Cretaceous genera, occurring abundantly in Europe in the Neocomian beds and not ranging higher than the Cenomanian. In describing *Requienia* (*Caprotina*) *texana*, Roemer asserted that it was hardly distinguishable from the characteristic *Caprotina lonsdallii* of the Neocomian of France.

Of the Gastropoda, the genus *Vycaria* is represented by *V. branneri* resembling a peculiar species of the European Neocomian, *V. lujani* De Verneuil and which in every variation is identical with the figures of the European species.

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* See various papers by Professors Lester F. Ward and W. M. Fontaine on the Potomac flora of the North Atlantic coast.

Natica (Tylostoma) pedernalis Roemer is characteristic of the Tylostomas of the Neocomian of France, Spain, and Portugal.

Of the *Nerinæas* in the Texas beds all have the archaic form of the Jurassic and lower Cretaceous (*Neocomian*) Nerinæas.

Only one echinoid is found in the Trinity Division, *Epiaster* (?), but this is of the older Cretaceous aspect of the European forms.

Of the *Ammonitidæ*, which in Europe are most relied upon for the classification of subdivisions of the Cretaceous, it may be said that the Comanche Series below the Washita Division is very deficient in these, only four species being known in America. Of two of these only three individual specimens have been found, while the European Neocomian abounds in many species and genera. Of the two genera with one species each found in the Trinity Division, it may be said that one of them, *Neumayria*, belongs to a genus which occurs in the Purbeckian, or uppermost Jurassic, and Wealden of Europe, and hence may be accepted as strong evidence that these beds are not of late Cretaceous age. The other species, *Acanthoceras* (?) *justinæ*, is too poorly preserved to be of criterional value.

While the writer has throughout placed the Trinity Division in the Cretaceous, he tried to defer final discussion of their age until opportunity should arrive for careful study of these fossils. Owing to constant labors in the field upon the more important stratigraphic problems, this opportunity did not arrive until now. At the time the Arkansas report* was written it was held that the Trinity beds might prove to be Jurassic, but the careful revision here presented tends to remove this doubt and enables us to assert their Cretaceous age with more assurance. Whatever doubt may have been inferred from any expressions in previous publications,† it may now be stated positively:

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* Op. cit.

† Through two unfortunate lapses in the typography of his former papers the attempt has been made to show that the writer did not hold the Cretaceous age of the Trinity Division, notwithstanding his repeated publications to the contrary. One of these is caused by the typographic error on page 84 of the report "On the Occurrence of Underground Waters," etc., Washington, May, 1892, where the clause "which are assumed to be the base of the true Cretaceous" is made to modify the words "Walnut clays," instead of "these beds," *i. e.*, the Trinity. The other lapse was of a somewhat similar nature in the previous publication on The Comanche Series of the Texas-Arkansas Region.

1. That there is not a single invertebrate species in the Trinity Division of exclusive Jurassic age, which would justify placing the beds in that period.

2. The genera all occur in the Cretaceous formations of the rest of the world, and many of them, such as *Requienia* and *Monopleura*, occur only in the Cretaceous. Hence the beds are Cretaceous.

3. The beds of the Trinity Division are of lowest Cretaceous age, Neocomian, because the genera all occur in the Neocomian or lowest Cretaceous of other countries, and because they contain none of the characteristic upper or middle Cretaceous forms.

Finally it may be stated that from the above comparison of the life of the Trinity Division with the Cretaceous life of Europe it is evident that it shows not only a resemblance, but a remarkable homotaxial similarity with the Lower or Neocomian of that country, the lowest faunas resembling the Wealden or Lower Neocomian, and the Upper Glen Rose beds the Middle and Upper Neocomian, especially as developed in the region of the Jura and in Spain and Portugal.

V.—DESCRIPTIONS OF SPECIES.

FORAMINIFERÆ.

Patellina texana (Roemer).

Plate I, Figs. 2 (copied after Roemer), 2*a*, 2*b*, 2*c*, 2*d*.

Orbitulites texana Roemer. Die Kreidebildungen von Texas, p. 86, plate x, figs. 7*a*, *b*, *c*, *d*.

"Shell minute, attaining one-eighth of an inch in diameter; orbiculate, shield-shape, convex above, obtusely conical; central eminence umboniform, ornamented with close, fine, concentric striæ, otherwise smooth; lower part flat, slightly concave, with irregular, radiating, granular rugæ, as if perforated by worms."—Roemer.

Roemer said: "This species certainly belongs to that group of Lamarck's genus *Orbitulites*, which D'Orbigny separated as a distinct genus *Orbitolina*." Careful microscopic study of the interior structure by the writer shows the granular structure illustrated in figs. 2*a*, 2*b*, and that it belongs to the genus *Patellina* of Williamson.

This important foraminifer was first found by Roemer on the upper branch of the Pedernalis, associated with *Tylostoma pedernalis.* I have found its true position to be in the medial portion of the Glen Rose beds, where, as on the Colorado near the mouth of Bull creek, it occurs in a massive chalk some ten feet thick. The "*Orbitolina*" beds are among the most characteristic and distinguishing features of the upper Neocomian of Europe, in the region of Jura, and in Dauphine, Portugal, and Spain. Their occurrence in a similar stratigraphic position in the Texas region is additional evidence of the Neocomian age of the Glen Rose beds. This Texas form has also been reported by Karsten from the Neocomian beds of Venezuela.

ECHINODERMATA.

Epiaster (?) sp. indet.

Only one echinoid has come under the writer's observation from the Glen Rose beds. It occurs about midway in the section, near Bull creek, Travis county, and in Somervell county, Texas. This has been submitted to Professor W. B. Clark, of Johns Hopkins University, who writes as follows concerning it: "I am inclined to think it not only a new species, but a new genus." The specimens are left in Professor Clark's hands for future determination.

VERMES.

Serpula paluxiensis sp. nov.

Plate I, Figs. 4, 4*a*, 4*b*.

Cylindrical tubicolate, marked by concentric lines of growth; occurs in colonies, radiating out from a central nucleus. Individuals several inches long, but it is impossible to trace complete length of specimens, owing to mode of growth. Adult specimens average one-eighth inch in diameter.

This is one of the most abundant forms in the basement horizon of the Glen Rose beds, and occurs attached to lignite, shells of *Ostreidæ*, and casts of other mollusks, or in immense colonies or spherical masses, some of which in Paluxy creek, averaging three feet in diameter, are composed entirely of this species.

The *Serpulas* have such wide geologic range and so few specific characters that they are of little value in geologic diagnosis.

Occurs at gypsum bluffs of the Little Missouri, and in great abundance at the plant bed near Glen Rose, and also throughout the extent of the lower fossiliferous Glen Rose beds in Texas.

MOLLUSCOIDEA.

Genus indeterminate.

Microscopic oval cells about one millimeter in length, growing in colonies attached to shell of *Serpula paluxiensis* and other forms; cells not overlapping, but in close contact with each other, forming a single layer of delicate net-work.

The cells of this species have not the pyriform shape or imbricated arrangement of *Membranipora* or the vibracular cells of *Lunulites*, and hence are assigned to no generic position at present. This form is the only one belonging to this order yet found in these beds. It occurs attached to other shells in the beds of the plant locality on the Paluxy near Glen Rose, Texas, at the base of the Glen Rose beds.

MOLLUSCA.

Anomia texana sp. nov.

Plate I, Fig. 5.

Anomia sp. indet. Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 135.

Thin, discoidal, indistinguishable specifically from many species of this genus; right or lower valve attached, concentrically laminated; left upper valve arched and very irregular; seldom exceeds one-half inch in greatest diameter.

This species abounds in the earliest fossiliferous horizon of the Trinity Division, such as the beds in Paluxy creek, west of Glen Rose, and at the gypsum bluffs of the Little Missouri, in Pike county, Arkansas. It also occurs in most of the localities throughout the extent of the Glen Rose beds.

Ostrea franklini Coquand.

Monographie du Genre Ostrea, p. 58, plate xxiii, figs. 8–10. Hill, Arkansas Geological Survey, Annual Report 1888, vol. II, plate v, figs. 1–18*a;* plate vi, figs. 19–25; plate vii, figs. 28–30.

The general aspects and variation of this characteristic oyster of the Trinity Division have been fully described and figured in my Arkansas report. Professor Marcou in a review of this work* has divided the form into many species, but the writer, from his extensive study of the occurrence of the specimens *in situ*, still believes in the unity of the species, although in Europe it has doubtless been the custom of earlier paleontologists to make many species out of variations.

Choffat† figures and describes from Portugal *O. barrosei*, a form which resembles a variety of *O. franklini* found at Glen Rose.

This species occurs in great abundance throughout the Trinity Division, especially at the plant beds near Glen Rose, at the base of the Glen Rose beds in the Colorado section, and in a similar horizon throughout the Glen Rose beds in Arkansas and in Texas.

It is interesting to note that none of the true *Gryphæas* or *Exogyras* have yet been found in the Trinity Division.

Ostrea franklini ragsdalei var. nov.

Plate I, Fig. 6.

Shell acuminate, oblong, marked by numerous, regular longitudinal costæ; beak of large valve prolonged, costate, sub-cylindrical.

Several incomplete specimens of the larger valve of this species were procured from the fauna at the plant bed near Glen Rose. The outline is somewhat similar to that of *O. franklini* Coquand, but the larger valve is much more round, the point more prolonged and characterized by the strong costæ which do not appear upon the adult specimens of the *O. franklini* elsewhere found.

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[*] American Geologist, vol. IV, December, 1889, pp. 359, 360.

[†] Recueil de Monographies Stratigraphiques Sur le Système Crétacique du Portugal, par Paul Choffat. Lisbon, 1885, p. 37, plate iii, figs. 7, 8, 9, 10, 11, 12.

This variety is named for Mr. G. H. Ragsdale, the naturalist, of Gainesville, Texas.

Thus far this variety has only been found at Glen Rose.

Pecten stantoni sp. nov.

Plate II, Fig. 3, *3a*.

Shell small, one and one-half inches in length, strongly eared, and ears rugose, the right one (not shown in figure) being marked by a deep fold. The surface of the larger valve is marked by strong, flattened, double ribs, each with a sinus its entire length, alternating with small single ribs, and by minute cross-lines. This marking distinguishes it from the *Vola*-like forms of the upper half of the Comanche Series. The smaller valve is not known.

This beautiful species occurs in the molluscan fauna at the plant bed on Paluxy creek, near Glen Rose; only three specimens have been found. Two of the specimens were very perfect, but were unfortunately lost in the removal of my collections from Cornell University.

This species is named for Mr. T. W. Stanton of the U. S. Geological Survey.

Modiola branneri sp. nov.

Plate V, Figs. 8, 9, 10.

Modiola sp. indet. Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate ii, figs. 18, 19.

Shell small, elongate, from one-half to one and three-quarters of an inch in length, elongated sub-triangulate, greatly thickened at umbonal region; umbones pronounced and rapidly narrowing to a rounded point; anterior portion somewhat flattened; posterior portion attenuated, thin, and strongly curving in outline; surface smooth, lustrous, marked by fine lines of concentric growth and faint radiating striæ.

This well-preserved little *Modiola* occurs sparingly in the lower Glen Rose beds at the gypsum bluffs of the Little Missouri, Arkansas, and in the plant bed near Glen Rose. It was originally figured, but not named, in my Arkansas report.

Leda (?) **harveyi** sp. nov.

Plate I, Figs. 7, 8.

Shell minute, one-sixteenth to one-eighth of an inch in length, elongate, smooth, concentrically striate; beaks situated at anterior third, blunt, thick, and recurving; posterior cardinal margin elongate, straight, or slightly concave; pallial margin straight or slightly sinuous; anterior cardinal margin short, straight; anterior margin very slightly rounded at base; posterior margin angular, short, and straight; anterior half of shell thick, subglobular; posterior half elongated, rapidly thinning posteriorly, and sometimes marked by a strong angular ridge extending from beak to union of pallial and posterior margin; cardinal area not exposed so as to show hinge mechanism.

This minute shell occurs in great masses, resembling small black specks in a calcareous cement, which under the magnifying glass reveals the outline shown in the figures; the hinge mechanism not seen.

Found thus far only at the plant beds of the Paluxy, near Glen Rose.

Named in honor of Mr. J. W. Harvey, who first collected from this locality, but died before the collections could be published.*

Cucullæa gratiota Hill.

Arca gratiota Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate ~~14,~~ figs. 2, 2*a*. Described and figured in my Arkansas Report as *Arca gratiota*. Occurs also in plant beds near Glen Rose, Texas, and in bluffs of Colorado.

Cucullæa comanchensis sp. nov.

Plate III, Figs. 1, 2.

Cordate, globose, thicker and higher than long, subquadrate in lateral aspect; posterior margin strongly truncate, pallial margin gently rounded; anterior margin short and truncate; exterior of cardinal area elongate and broad; umbones small, high, and incurved, but not touching; shell thick, rough, and marked by strong, irregular, rugose lines; hinge mechanism not visible.

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*See American Geologist, October, 1892.

This is one of the most characteristic species of the very base of the Glen Rose beds in Parker, Hood, and Comanche counties, and is the form which the writer once inferred to be analagous to *Ambonicardia cookii* Whitfield,* from the Raritan clays of New Jersey, which the fragments then found strongly resembled in outline and marking. The discovery of the specimen here figured, however, for the first time affords evidence for their satisfactory generic identification.

The specimen figured was found about three miles east of Millsap, Texas, at the contact of the Trinity sands and the calcareous Glen Rose beds. I have also found the species near Springtown, Parker county, and at Comanche, in the same horizon.

Cucullæa terminalis Conrad.

(See Report United States and Mexican Boundary Survey' Washington, 1857, vol. I, p. 148, plate iv, figs. 2*a* and *b*.)

Casts of this species are frequently met with in the Glen Rose beds. The shell has not yet been found.

Barbatia parva-missouriensis Hill.

This species, from Pike county, Arkansas, was described and figured in my Arkansas Report, p. 133, plate iv, figs. 4*a*, 4*b*, 5, and probably fig. 22, of plate ii, of same report.

Trigonia stolleyi sp. nov.

Plate III, Figs. 3 and 5.

Semi-lunate in general outline, beaks well forward and strongly recurved; anterior and pallial margin a strong continuous curve; posterior portion elongated with truncated posterior margin; cardinal area compressed. Surface marked by flexuous, noduled costæ, about twenty-two in number, narrow and high, separated by broad intercostal areas as in *T. alæformis* Lmk.; depressed cardinal area bordered on its outer side by a long narrow groove and marked by cross-ribs, flexing anteriorly.

This *Trigonia* differs from *T. emoryi* Conrad, of the Washita Division, in its general outline and entirely distinct surface marking. (See U. S. and Mexican Boundary Report, vol. I, p. 148, plate iii, figs. 2*a*, *b*, *c*.) Occurs abundantly in the plant beds of the Paluxy. The species is named for Professor G. W. Stolley, of Austin, Texas, whose work as a collector is esteemed in both Europe and America.

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*See Report of Arkansas State Geological Survey for 1888, vol. II, p. 126.

Trigonia crenulata Roemer.

Plate III, Fig. 4.

Roemer. Kreidebildungen von Texas, p. 51, plate vii, fig. 6.

This species, described by Roemer from imperfect casts, may be the same as *T. stolieyi.* The specimen here figured was collected from the bluffs of the Colorado near Bull creek, Travis county.

Chione (?) **decepta** sp. nov.

Plate I, Figs. 9 and 10.

Shell sub-triangulate or elliptical in outline, compressed in cross-section from base to umbones; umbones forward of center, small, and touching each other; lunular area small, cordate oval; pallial margin widely rounding; anterior cardinal margin concave, shorter than posterior; posterior cardinal margin long, slightly convex, asymmetrical; cardinal mechanism not shown; surface marked by long concentric and very faint irregular lines, anterior muscular scar elongate, rounded; posterior muscular impression flat, depressed at extreme posterior end.

The casts of this form are abundant throughout the Glen Rose beds, but its generic position is uncertain. It may possibly belong to the *Carditidæ.* In the hills north of Lampasas, near the top of the formation, the specimens occur in great abundance with the shell preserved in calcite, showing the exterior structure. Conrad's species of *Astarte texana*,* described from a cast from an unknown locality, has a superficial resemblance to this form, according to his description and figures, but it is more triangular and otherwise different, as seen by comparison with his type in the National Museum.

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* U. S. and Mexican Boundary Report, vol. I, p. 152, plate v, fig. 9.

Eriphyla pikensis Hill.

Plate IV, Figs. 4, 5, 6.

8 ?

Corbicula pikensis Hill. Arkansas Geological Survey, Annual Report 1886, vol. II, p. 134, plate ii, figs. 13, 13*a*, 14, 15, 16, 17.

This form was originally figured by the writer under the generic name of *Corbicula*, and is very closely allied to the so-called *Cyrena astarteformis* Koch and Dunker, from the Wealden of Germany. Professor Marcou has referred it to the *Astartidæ*, but it is undoubtedly a species of the genus Eriphyla of the Astartidæ distinguished by the lateral teeth.

It occurs in great abundance in Pike county, Arkansas, and sparingly at the plant bed of the Paluxy, near Glen Rose, Texas.

Requienia texana (?) (Roemer).

Caprotina texana Roemer. Kreidebildungen von Texas, p. 80, plate v, figs. 2*a*, 2*b*.

A *Requienia*, provisionally referred to *R. texana* Roemer, is one of the prominent species of the Glen Rose beds and occurs in massive agglomerate some twenty feet in thickness at Glen Rose, Thorp Springs, Granbury, and in southern Parker county. In Roemer's description he asserts that it is indistinguishable from *Requienia lonsdalli* D'Orb., of the French Neocomian, except by its thicker shell. It is desirable to closely compare this form with *R. patagiata* White.* Dr. Roemer says that the latter species is entirely distinct, the larger valve of *R. texana* not being so elevated as in *R. patagiata*. In the abundant material collected by the writer this distinction does not always hold good, yet there is a general difference in appearance, especially in the larger size and more rounded character of the valves of the Glen Rose forms, which may make it a distinct species from either of these. The type forms of the *R. texana* Roemer and the *R. patagiata* White occur in the horizon which we at present accept as the Caprina limestone, while the *Requienias* of the agglomerate at Granbury and at the base of the Colorado section occur several hundred feet below them, and may prove a distinct species.

Requienia is the lowest occurring genus of the aberrant Chamidæ, with the exception of Diceras, a Jurassic form, and is abundant in the Neocomian formation of Spain, France, and Portugal.

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* *Requienia patagiata* White. U. S. Geological Survey, Bulletin No. 4, p. 6, plate v, figs. 1-8.

Monopleura marcida and **M. pinguiscula** White.

Bulletin U. S. Geological Survey, No. 4, p. 8, plate 5, figs. 1–8.

Casts and moulds of *Monopleura* occur in great abundance in the Colorado section, especially at the base of Mount Bonnel, near the mouth of Bull creek. It is impossible to make a correct diagnosis of these, owing to the fact that the smaller valves, so abundant in the Caprina limestone, have not been found in the Glen Rose beds, but there is a general resemblance of the larger valves to the two species named.

The genus *Monopleura*, according to Zittel, has wide distribution in the Lower Cretaceous, occurring in the Neocomian of Provence and the Jura mountains, and seldom ranging higher. In America the genus culminates in the Caprina limestone and is not known later.

Corbicula arkansaensis Hill.

Arkansas Geological Survey, Annual Report 1888, vol. II, p. 133, plate ii, fig. 20; plate iv, figs. 3, 3*a*, 6.

This species was originally figured and described in my Arkansas report. It occurs in Pike county, Arkansas, near Murfreesboro, and at the gypsum bluffs of the Little Missouri. It is less abundant in the Texas beds.

Cardium (?) **sevierense** Hill.

[?Arkansas Geological Survey, Annual Report 1888, vol. II, p. 134, plate ii, figs. 21, 21*d*.

This form has only been found in Arkansas. at the locality from which it was described in my Arkansas report.

Protocardia sp. indet.

Small casts, three-quarters of an inch in length, globose; surface marking, very fine lines.

The Comanche species of the genus *Protocardia* need careful revision, and this form may be found to belong to some of the numerous species already described. This species is distinguished only by a smaller size than that of all the other forms described. It occurs sparsely in the beds near Glen Rose.

Pholadomya knowltoni sp. nov.

Plate II, Figs. 1, 2.

Choffat (Matériaux pour L'Étude Stratigraphique et Paléontologique de la Province D'Angola, Geneva, 1888, p. 84, plate v, figs. 1–3) describes under the name of *P. pleuromyæformis* a form indistinguishable from this species. His description, as follows, corresponds fully with our species:

> "Equivalve, inequilateral; swollen below the beaks; anterior border rounded and completely closed; posterior border compressed at the extremity, which is slightly turned upward, truncated and slightly gaping; beaks small, elevated, strongly inflexed and in contact with each other; cardinal portion of anterior border sloping and its continuation strongly rounded; the posterior cardinal border straight, slightly elevated to its extremity; anterior face blunt, behind which a slight, faint groove extends from the beak to the pallial border. The surface of the shell is marked by irregular longitudinal plications."—Choffat.

This shell can in no way be distinguished from the excellent figures and descriptions given by Choffat of *Pholadomya pleuromyæformis*, from Dombey, on the west coast of Africa, where a fauna closely allied to the Comanche series occurs, but of course their identity cannot be positively established without comparison of specimens. The faint grooves from beak to pallial border are not brought out well in our figures.

The form first appears in America in the medial portion of the Glen Rose beds of the Colorado river section, near the mouth of Bull creek, and again appears in the supposed Caprina limestone at Austin, in the Fredericksburg Division.

Pholadomya lerchi sp. nov.

Plate IV, Fig. 3.

Outline subpyramidal in lateral aspect; length, three and one-half inches; height, two and one-half inches; greatest thickness, two inches; beak situated at anterior third, of medium proportions; anterior margin semicircular in outline from beak to pallial margin, into which it merges by a continuous curve; pallial margin a continuous curve with the anterior margin, and rapidly increasing in curvature posteriorward, terminating obtusely with the truncated posterior margin; posterior margin sharply truncate, about one inch in length; anterior umbonal margin very short, marked by a small depression immediately below the umbone; posterior umbonal margin elongate, sloping posteriorly at an angle of about 30 degrees from the umbone; this margin is straight when viewed laterally, but bends strongly outward toward the gaping posterior margin, with which it unites by a gentle curve; surface marked by strongly rounded ribs and grooves, subconcentric, sinuous and uniting with each other at a common groove which is parallel with the anterior margin.

Only a single poorly preserved cast of a right valve of this species has been found, the anterior portion of which is not visible. It was collected in the heavy conglomerate which marks the base of the Comanche Series at its contact with the Carboniferous formation, on Sycamore creek, Burnet county, Texas, near the crossing of the Burnet and Travis Peak roads. The species is named for Dr. Otto Lerch, of the Louisiana State Geological Corps, who, as a Texan, has made valuable contributions to the knowledge of his State.

Pleuromya (?) **henselli** sp. nov.

Plate IV, Figs. 1, 2.

Shell elongate-elliptical; length, three and one-quarter inches; height, two inches; umbones anteriorly subcentral, round, and not prominent; anterior margin strongly rounded, continuing by curvature into the pallial margin; pallial margin elongate, slightly curved; posterior margin sub-truncate, slightly gaping; anterior umbonal margin sinuous, slightly gaping; posterior umbonal margin about one-third longer than anterior; interior and hinge mechanism not seen.

The generic position of this species is very doubtful; but, inasmuch as it is one of the most characteristic casts of the Glen Rose beds in the Colorado River section, it is important that it should be here figured. The species has a resemblance to *Thracia myæformis* White, but differs in some details.

Isocardia (?) **medialis** (Conrad).

Plate II, Figs. 4, 5; plate III, Fig. 6.

Cardium mediale Conrad, U. S. and Mexican Boundary Report, vol. I, p. 149, plate iv, figs. 4*a*, *b*.

Conrad described this form as follows:

> "Cordate equilateral, ventricose; base profoundly and nearly regularly rounded; beaks prominent; posterior margin truncated, direct."

To this I would add:

Variable in shape; shell thick, concentrically striate; beaks inturned as in *Isocardia;* anterior muscular impression very prominent, angular on anterior side; posterior muscular impression faint, large in area, almost indistinguishable; posterior margin truncate in normal specimens. Surface marked by strong concentric rugose lines.

The generic position of this form is not satisfactory, because the hinge structure has not been found. It is clearly not a *Cyprina*, although sometimes similar forms are referred to that genus by paleontologists in Europe; neither is it a *Cardium* as described by Conrad.

This is one of the most numerous, conspicuous, and characteristic species of the Glen Rose beds; it occurs as shelless casts by the thousands throughout the vertical and geographic extent in Texas and Arkansas, beginning in the lowest fossiliferous horizon and extending to the top.

A few specimens were found about ten miles west of Glen Rose, upon which fragments of the thick calcified shell structure were preserved, showing it to have a concentrically striated surface and the anterior cardinal margin and beaks to be as in *Isocardia*, as shown on plate vii, fig. 1.

The form varies greatly in shape, owing to the compression and distortion it has undergone in the strata. One of the extreme variations from the normal is illustrated on plate ii, fig. 5.

Natica (?) **texana** Conrad.

U. S. and Mexican Boundary Survey, p. 157, plate xiii, figs. 1*a*, *b*.

This species is of rare occurrence in the beds at Glen Rose. It is not a *Natica*, but inasmuch as only casts are preserved its generic position cannot otherwise be stated.

Viviparus (**Natica** ?) **cossatotensis** Hill.

Arkansas Geological Survey, Annual Report 1888, vol. II, p. 130, plate iii, figs. 4, 4*a*, 5, 5*a*.

This form was originally described in my Arkansas Report from an isolated locality in Sevier county. Many consider it a *Natica*, but it is too imperfect to assert its generic position with certainty. The writer inclines to the belief that it is a fresh or brackish water form.

Cylindrites (?) sp. indet.

The writer has collected from the base of the Glen Rose beds in Parker county a few specimens of a small gasteropod very much resembling *Cylindrites bullatus* Lyc. and Mort. Unfortunately the specimens have been lost.

Buccinopsis (?) **parryi** Conrad.

Plate VI, Fig. 1.

U. S. and Mexican Boundary Report, p. 158, plate xiii, figs. 4*a*, *b*.

B. Conradi Hill. Arkansas Geological Survey, Annual Report 1888, vol. II, p. 130, plate iii, figs. 2, 2*a*.

Conrad describes this species as follows:

"Subpyriform; longitudinally undulated and ornamented with rugose, revolving lines, spire scalariform; aperture large and patulous." Conrad also says: "Under this name I have described a cast which cannot be referred to any known genus; it is certainly not a true Buccinopsis, nor can its generic character be determined because of poor preservation."

The writer has found casts of this form in great abundance in the lower fossiliferous horizons of the Glen Rose bed at gypsum bluffs of the Little Missouri, in Arkansas, and at Glen Rose. In some instances the casts show marks in the shape of depressions extending across the lower whorl and the sutures are very deep and distinct. The whorls and spire of a more perfect specimen, shown in plate vi, fig. 1, are six in number and very flat and angular at their upper edge. Whatever may be the true generic position of this form, it is a very useful stratigraphic aid to the student of the Glen Rose beds. The form is readily distinguishable from *Tylostoma pedernalis* Roemer by its greater number of whorls and entirely different outline of the aperture.

Tylostoma pedernalis (Roemer).

Plate VI, Fig. 2.

Natica pedernalis and *N. prægrandis* Roemer. Kreidebildungen von Texas, p. 43, plate iv, figs. 1*a*, *b*; plate iv, figs. 1*a*, *b*.

"Shell large, ovate; whorls flat, angular above; lowest or basal whorl three times as high as the spire; spire composed of three coils. Aperture, elongate ovate."—Roemer

Dr. Roemer described this large and abundant species of the Glen Rose beds from specimens collected on the Pedernalis river. He also described *Natica* (*Tylostoma*) *prægrandis*, which he asserted differed only by its larger size.

The species occurs in the greatest abundance throughout the extent of the Glen Rose beds in Arkansas, Texas, and Mexico, and is preserved only as casts, without shell structure. From observations of hundreds of individuals, I am of the opinion that the two species of Roemer are identical.

These forms are indistinguishable from many species described from the Neocomian of France and Spain, where the genus *Tylostoma* has its culmination, ranging, according to Zittel, from the Upper Jurassic. *Tylostoma similimum* Choffat, from Portugal, a characteristic Neocomian form, is quite closely related, if not identical with the Texas species. It also resembles *N. gigas* Bonn. of the Jurassac.

The specimen figured here is a large flattened individual, illustrated in order to show the size and variation in comparison with the typical forms figured by Roemer.

This form occurs throughout the Neocomian of Mexico, in Venezuela, Bogota, and on the central Pacific coast of South America, and is one of the distinguishing fossils of the Glen Rose beds.

Vicarya branneri sp. nov.

Plate V, Figs. 1–7.

Pleurocera strombiformis (Schlotheim) Hill. Neozoic Geology of Southwest Arkansas, p. 129, plate ii, figs. 1, 2, 3, 4, 5, 6, 7, 7*a*, 7*b*, 8, 9, 10, 11, 12, 12*a*; plate iii, figs. 6, 6*a*, 6*b*, 6*c*, copies of European figures.

Compare—

Vicarya helvetica Verneuil and De Lorière. Description des Fossiles du Néocomien Supérieur de Utrillas et ses Environs, p. 2, plate i, fig. 1.

Vicarya lujani Verneuil and De Lorière. Ibid., p. 5, plate i, fig. 3.

Vicarya strombiformis Verneuil and De Lorière. Ibid., p. 7, plate i, fig. 4.

Vicarya pradoi Verneuil and De Lorière. Ibid., p. 10, plate i, fig. 5.

Turritella helvetica Pictet and Renevier. Mater. pour la paléont. Suisse du ter. aptien, 1854.

Cassiope helvetica H. Coquand. Monogr. paléont. de l'ét. aptien de l'Espagne, 1866.

Cerithium lujani Verneuil. Bull. de la Soc. Géol. de France, 2e liv. Tome x, 1853.

Cerithium luxani Verneuil. Memoria geognostica de Castellon par Vilanora, 1859, plate iii, Fig. 7.

Cassiope verneuilli H. Coquand. Monogr. paléont. de l'ét. apt. de l'Espagne, 1866.

Murex strombiformis Schlotheim. 1820, Petrefact., p. 144.

Muricites strombiformis Schlotheim. Monographie der Norddeutschen Wealdenbildung, Dunker, 1846, p. 50, pl. x, fig. 18*a*, *b*.

This form is indistinguishable from the figures of *V. lujani* and *V. helvetica* of De Verneuil and De Lorière, but without comparison of type specimens their identity cannot be positively asserted. *V. lujani* is described as follows:

"Shell elongated, with thick test; spire regular, straight, or sometimes a little pupoid; ten or twelve turns of the spire. Each turn of the spire is marked by numerous sinuous cross-striæ, strongly bent inward upon the first anterior quarter of each spiral. The sutures are generally well defined." The whorls are also usually marked by two longitudinal elevated bands, one near each border, which in the apical whorls and adult specimens appear as plain elevated bands, or may be in the lower two-thirds of the shell nodular. They continue upon the buccal face or base of the shell as bands. "The lip always presents at the posterior or upper end a pronounced gutter. The outer lip has a deep, broad indentation corresponding with the termination of the basal suture line beneath the last carina or row of tubercules. The inner margin of the labial opening is thickly encrusted."—De Verneuil.

This is one of the most abundant, variable, and characteristic forms of the Trinity Division, occurring in the lowest molluscan horizons of the Glen Rose beds throughout its extent from Antoine, Arkansas, to the Colorado river in Texas. It was first figured from America by the writer in his report upon the Cretaceous beds of Arkansas under the name *Pleurocera strombiformis* Schloth., after Zittel. Although a very abundant form, the oral aperture was only recently discovered, it having hitherto been broken in the delicate structure of the specimens, and the generic position thereby made uncertain, as is attested by the widely different genera to which it has been referred in Europe.

The smallest and largest forms are void of the handsome rows of tubercules which distinguish the specimens of medium size. The larger adult specimens sometimes attain a length of two inches.

This form is of interest because it is the characteristic species of the Wealden (Lower Neocomian) beds of Europe. It may be the same as *Melania strombiformis*, first described from the Wealden strata of North Germany by Schlotheim.

De Verneuil and De Loriere, in 1886, published most excellent figures and descriptions in their paper upon Matèrieux pour le Paléontologie de l'Espagne, entitled "Description des Fossiles du Neocomien Superieur de Utrillas et ses Environs," Paris, 1868. They review the literature of the species and refer it to the *Vicarya*, a subgenus of *Cerithidæ*. They make four distinct species of their specimens, which I believe to be variations of the same species, all of which except one occur in intimate association in the lower Glen Rose beds.

Professor Jules Marcou, in the previously mentioned review of my Arkansas species, asserts that the form is a *Nerinæa*, but the forms are absolutely void of the characteristic folds which occur upon the columella of that genus, and hence he is mistaken.

The form occurs in great abundance at the gypsum bluffs of the Little Missouri, in Arkansas. At the plant bed locality near Glen Rose, Texas, it is still more abundant and shows the variety *helvetica* and *lujani* preserved together in great masses. At Post Mountain, near Burnet, Texas, the badly worn shells of this species occur in an agglomeration ten feet thick (plate v, fig. 7), void of other species and embedded in a matrix of the mineral grahamite. In this mass all the varieties can be found in association.

Nerinæa austinensis Roemer.

Roemer. Paleont. Abhandl., vol. IV, p. 295, plate 31, fig. 8.

Fragments resembling this species are abundant in the upper or Mount Bonnel beds of the Glen Rose beds, but are so poorly preserved as to render their assignment to it only provisional. I have found them in the Strontionite beds of the Colorado section, and a stratum of the beds near the summit of Mount Bonnel consists almost entirely of calcified *Nerineas*. In outer marking they correspond to the *N. austinensis* of Roemer, originally collected from the Caprina limestone near Austin.

The *Nerineas* do not occur in the Comanche series higher than the Caprina limestone of the Fredericksburg Division and not at all in the Upper Cretaceous, where Roemer erroneously supposed this species (originally collected by Mr. Stolley) to occur.

Neritina sp. indet.

A characteristic fossil of the beds at the base of the Glen Rose subdivision is a small *Neritina.* Unfortunately the writer's specimens were lost in the removal of his collections to Washington, but there are others in the United States National Museum, which he collected from Hood county for the United States Geological Survey in 1886, and it is hoped that they will be figured and described.

This form occurs throughout the basement beds in Arkansas and in Hood and Parker counties, Texas.

Neumayria walcotti Hill.

Plate VIII, Figs. 1, 2, 3.

Ammonites walcotti Hill (not Sowerby). Annual Report Geological Survey of Arkansas 1888, vol. II, p. 139, plate i, figs. 1, 1*a*, 1*b*.

Nikitin (Mem. de l'Acad. St. Petersburg, 1881), defines this genus as follows:

> Shell flat, widely umbilicate; convolutions thinly rounded, marked by fine falcate lines; lobes and saddles low, slightly incised; siphonal lobes longer than the first laterals; the two lateral and accessory lobes little developed.

Only one specimen of this species has thus far been discovered. It occurred in association with *O. franklini*, *Vycaria lujani*, *Eriphyla arkansaensis*, and other mollusks herein described. The form very much resembles in outward appearance the figures of the genus *Oxynoticeras* of Hyatt, as given by Zittel and Steinman in their Manuals, but Professor Hyatt refers to it to *Neumayria*, and contributes the following comments upon the specimen:

"Your *Ammonites walcotti* is probably a *Neumayria.* The aspect is Jurassic, but this group, Upper Jura, and the species nearest *walcotti* occurs in the very top of the Jura of Central Volga stage, supposed by some to be similar to the Purbeck in the upturn at Malm. The obscuration of a portion of the sutures occurs over the most important part of the outer side, and the structure of the abdomen, which is rounded and has no keel, is not very consistent with the reference either to the *Neumayria* of the Jura or the so-called *Neumayria* of the Cretaceous. Nevertheless it agrees better with those of the Jura than the Cretaceous ones referred to the same genus by Nikitin."

Whatever may be the range of this genus in Europe, the writer is inclined to the belief, from the stratigraphy and association, that its occurrence in Arkansas is lowest Cretaceous, and Professor Hyatt's opinion serves to strengthen the position of the writer in his reticence in earlier papers in expressing a more definite assignment of the Trinity beds before minutely studying the accompanying faunas. The specimen was collected in the banks of Town creek, one mile southeast of Murfreesboro, Arkansas. Named in honor of Mr. C. D. Walcott.

Acanthoceras (?) **justinæ** sp. nov.

Plate VII, Figs. 1, 2, and 3.

Discoidal thin and flattened in general outline, deeply umbilicate, marked by numerous simple, gently sinuous ribs extending across the convolution and separated by shorter ribs, which disappear near the middle of the convolution; abdomen oblately rounded; suture lines not preserved in specimens found; umbilicus (fig. 2) narrow, depressed.

This species occurs in a coarse sand in the Trinity beds of Travis Peak post-office, in western Travis county, Texas, only four specimens having thus far been found. It is preserved as a cast, unpropitious for the preservation of the shell structure. It is the only ammonitic form thus far found in the Trinity Division, excepting *Neumayria walcotti*, but is of little value in determining the stratigraphic position of these beds.

Professor Hyatt has provisionally referred it to the family *Acanthoceratidæ*, and suggests a resemblance to *A. remondii* Gabb, from the Cretaceous of California. Our species, however, in the writer's opinion, is quite different in general aspect, being very much more flattened, more rectangular at the dorsum, and possessing wider convolutions. It has some external resemblance also to the genus *Hoplites*.

ARTHROPODA.

Cypridea texana sp. nov.

Plate I, Figs. 3, *3a*, *3b*.

Shell microscopic; elongate ovate globose, with angular appendage shown in fig. 1; opalescent or horny; cardinal margin toothless, thickened centrally; opposite or ventral margin slightly undulate; surface smooth, and not visibly punctate.

It is difficult, says Zittel, to classify with certainty even the families of the Ostracoda, owing to the fact that the shell only is preserved, which is not sufficiently differentiated to justify exact diagnosis. The species here given occurs in abundance in the Glen Rose beds, but usually only the merest outlines are preserved, or mere granules which suggest the form. In the molluscan fauna at the plant bed of the Paluxy, near Glen Rose, however, I was so fortunate as to secure a small fragment in which the shell structure was well preserved. That the species belongs to the *Cypridæ* is strongly probable, resembling both the genera *Cypris* and *Cypridea*. I have placed it in the latter provisionally, because it is a marine form, occurring in masses of marine shells or mollusca, while the former genus is a fresh water one and of more recent occurrence.

There are large masses of sub-oolitic material in the Mount Bonnel beds, which are apparently largely composed of these minute Crustacea. The *Cypridæ* are also abundant in the Lower Neocomian, or Wealden, of Europe.

PLANTÆ.

Undetermined species.

Plate I, Figs. 1, *a*, *b*, *c*, *d*.

(" Goniolina ? " of author's previous writings.)

Spherical cone-like bodies, varying in size from three-quarters to one and one-half inches in diameter; slightly elongate, oblate or depressed at upper end, with well defined circular scar showing attachment to receptacle; surface consists of minute imbricate scales, usually worn down or indistinct; scales elongate ovate or sub-diamond-shaped, elongated toward upper end, and crowded around receptacular scar; seed minute.

This problematic organism has been provisionally referred to *Goniolina* in my previous papers. It occurs from the base to the top of the Glen Rose beds as small spherical calcareous casts, and extends into the lower layers of the Comanche Peak group at Mount Barker, Travis county. The biologic relations of this organism have been a problem for years, and it has been referred to the Echinodermata, the Foraminifera, and to the vegetable kingdom by various persons to whom it has been submitted. Its occurrence in the chalky strata of the Colorado section remote from other land débris and in association with Foraminifera (*Orbitulites texana* Roemer) seemed to oppose the fact that it was a fruit or a land plant. The recent discovery by Mr. J. W. Harvey of other plants of many species in the chalky limestone beds near Glen Rose, which have recently been described in the proceedings of the United States National Museum by Professor Fontaine, dispelled the foregoing hypothesis. Immediately beneath the stratum containing the plant bed is another containing many flattened moulds of what could be mistaken for fucoid stems, and associated with these are numerous specimens of the fossil here figured. A careful study *in situ* of the surface of a stratum in which these stems were well exposed showed that they branched very much like coniferous plants. At the termination of each ramification was found one of the small spherical casts, as if the limb of a plant laden with cones had been buried in the mud and its cast preserved. Recently, however, the fruit structure has been determined in the specimens themselves as figured on plate i.

The species should be named for Professor Lester F. Ward, who has done so much for American paleo-botany and has ever encouraged the writer in his studies.

The form occurs from Glen Rose southward to the Colorado in great quantities and ranges throughout the Colorado River section.

It could be doubtfully referred to the genus *Araucarites*, which it more closely resembles than any other, although this is for the botanists to determine. This genus is abundantly represented in the Wealden (Lower Neocomian) of Europe and in the Potomac formation of this country, as described by Professors Ward and Fontaine.

PLATE I.

FIGURE 1.—An undetermined plant.
- 1*a*.—Imbricate scales of cone (?), enlarged.
- 1*b*.—Imbricate scales (worn) showing seeds (?).
- 1*c*.—Scars, apparently attachment of seeds.
- 1*d*.—Outlines of scales and seeds (?) on worn surface.

FIGURE 2.—Pattellina texana (Roemer). (Copy of Roemer's figure of Orbitulites texana.)
- 2*a*.—Cross-section, showing irregular structure of interior.
- 2*b*.—Portion of base, showing irregular granular structure.
- 2*c*.—Pores of upper surface, greatly magnified.
- 2*d*.—Labyrinthoid pores of another part of upper surface, magnified.

FIGURE 3.—Cypridea texana sp. nov.
- 3*a*.—Ordinary aspect of shell.
- 3*b*.—Ventral border of union of valves.

All magnified 100 times.

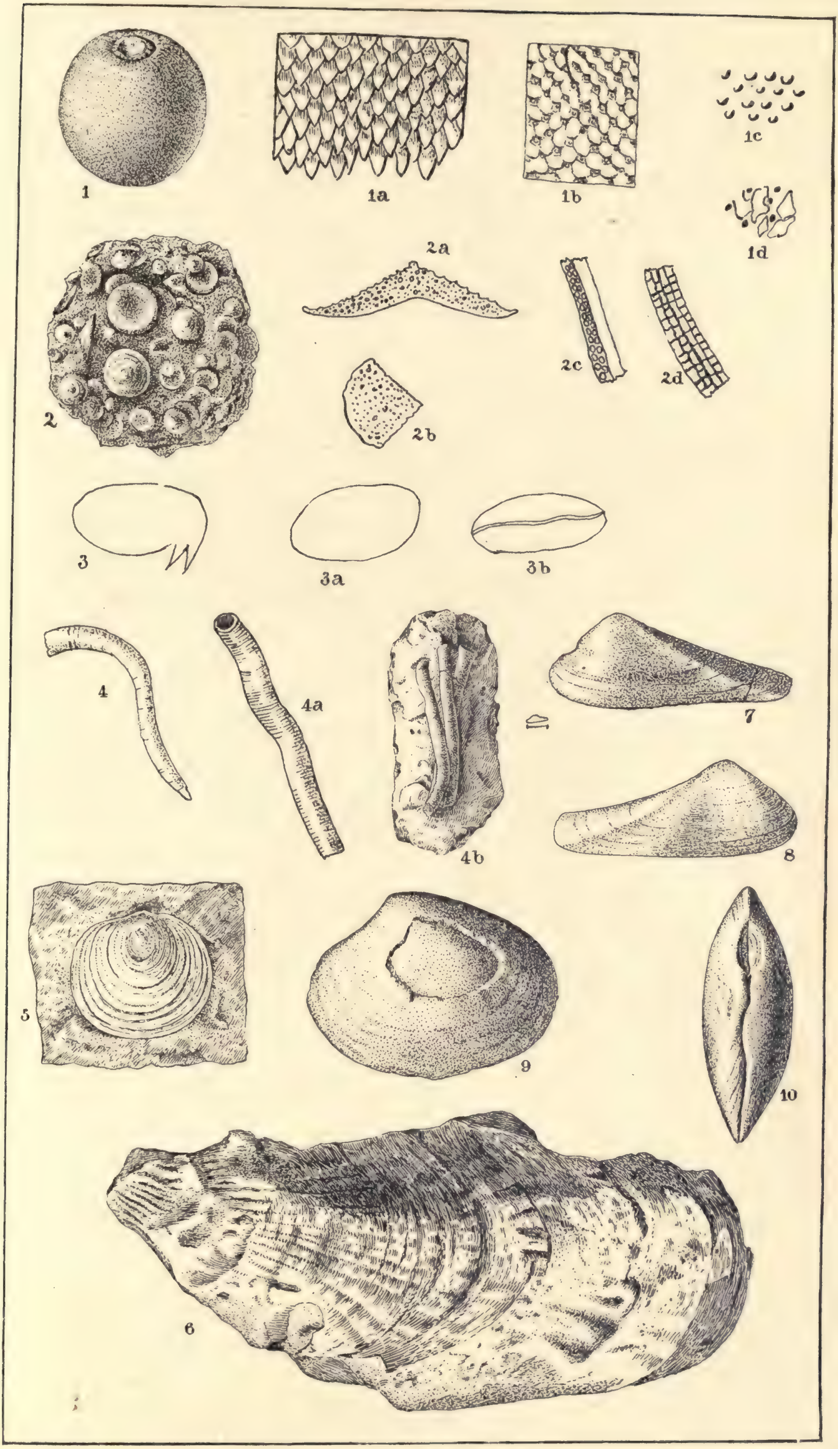
FIGURE 4, 4*a*, 4*b*.—Serpula paluxiensis sp. nov.

FIGURE 5.—Anomia texana sp. nov.

FIGURE 6.—Ostrea franklini ragsdalei var. nov.

FIGURES 7, 8.—Leda harveyi sp. nov. Magnified 20 diameters.

FIGURES 9, 10.—Chione (?) decepta sp. nov.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1a
1b
1c
1d
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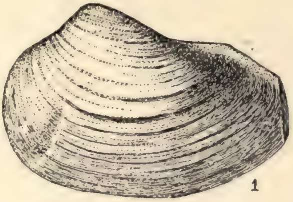
INVERTEBRATES OF THE TRINITY DIVISION—HILL.

PLATE II.

FIGURES 1, 2.—Pholadomya knowltoni sp. nov.
FIGURE 3.—Pecten stantoni sp. nov.
3*a*.—Detail of marking of larger valve.
FIGURE 4.—Isocardia (?) medialis (Conrad).
FIGURE 5.—Distorted specimen.



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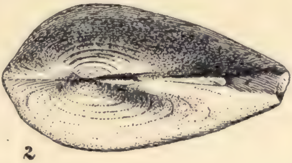

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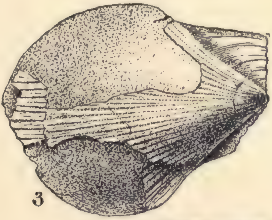

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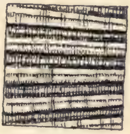

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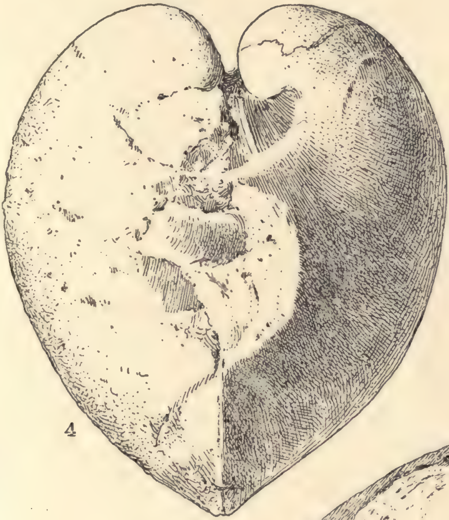

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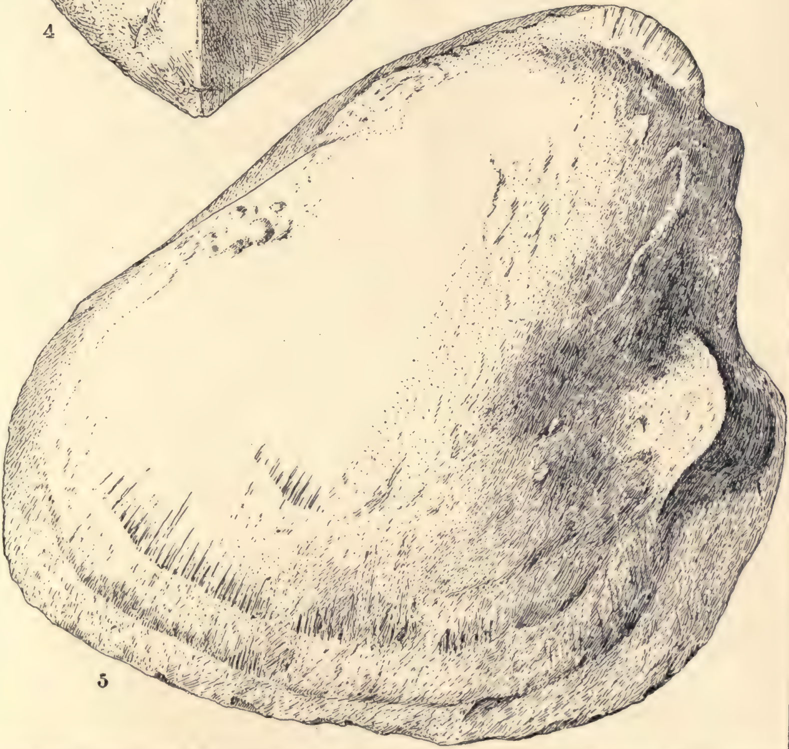

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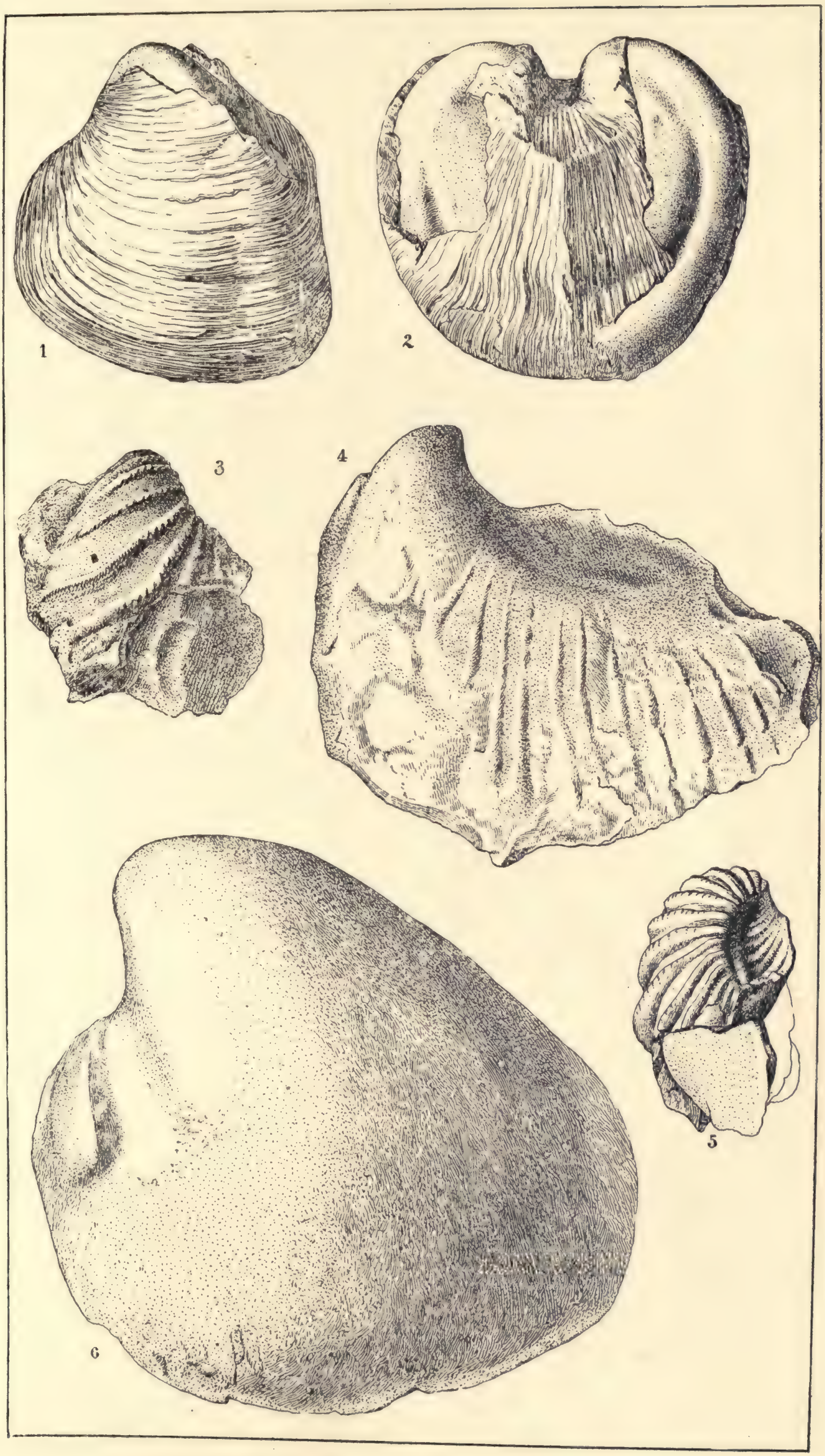
INVERTEBRATES OF THE TRINITY DIVISION—HILL.

PLATE III.

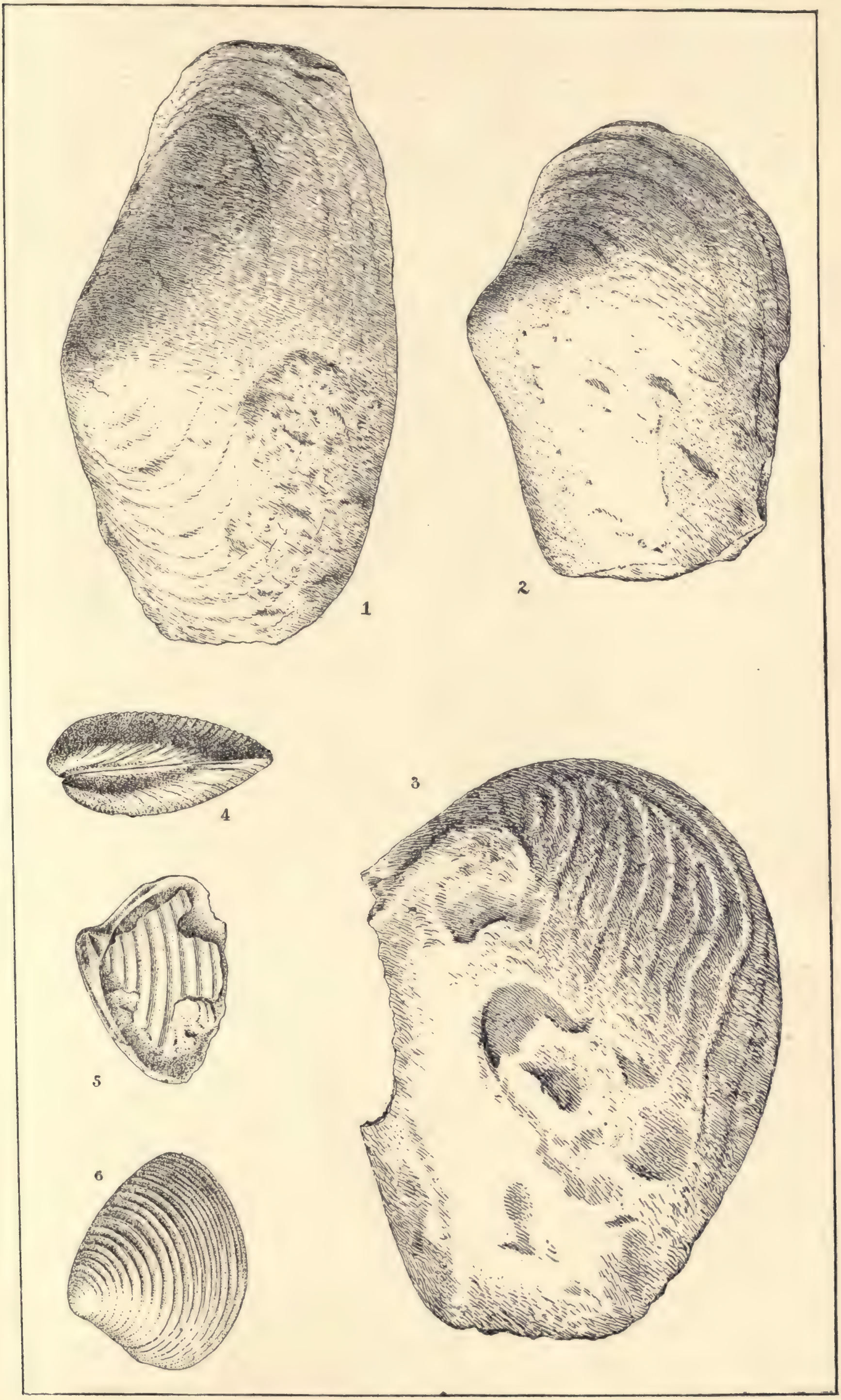
FIGURES 1, 2.—Cucullæa comanchensis sp. nov.
FIGURES 3, 5.—Trigonia stolleyi sp. nov.
FIGURE 4.—Trigonia crenulata Roemer.
FIGURE 6.—Isocardia (?) medialis (Conrad).



INVERTEBRATES OF THE TRINITY DIVISION—HILL.

Plate IV.

Figures 1, 2.—Pleuromya (?) henselli sp. nov.
Figure 3.—Pholadomya (?) lerchi sp. nov.
Figures 4–6.—Eriphyla pikensis Hill, magnified 2 diameters.



INVERTEBRATES OF THE TRINITY DIVISION—HILL.

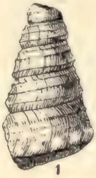
Plate V.

Figures 1–4.—Vicarya branneri sp. nov., showing marking of younger forms (V. lujani variety. Magnified 2 diameters).

Figures 5, 6.—Vicarya branneri (V. helvetica variety). Adult form, showing aperture.

Figure 7.—Vicarya branneri. Mass, showing occurrence of species and variations.

Figures 8–10.—Modiola branneri sp. nov. Magnified 2 diameters.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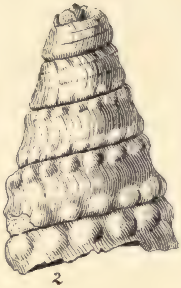
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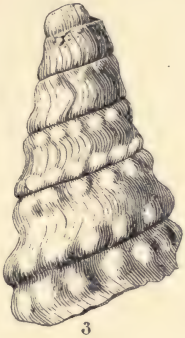
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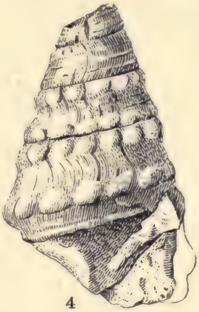
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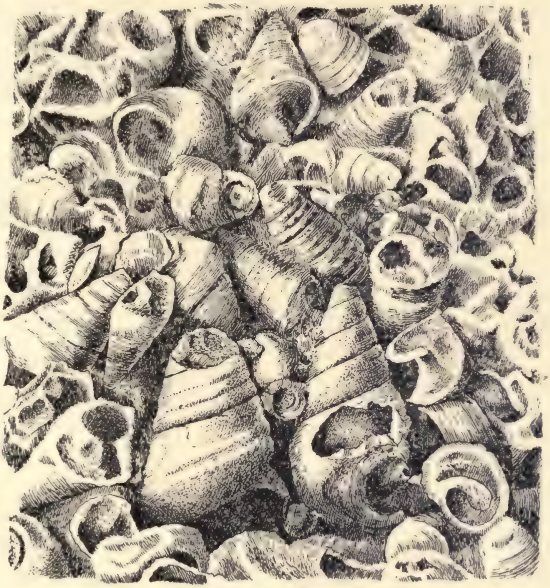
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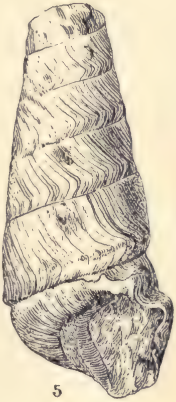
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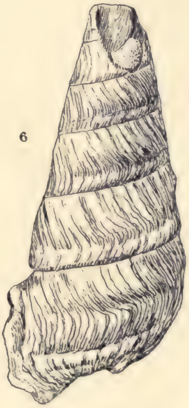
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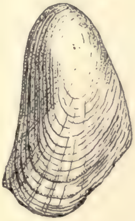
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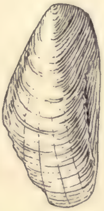
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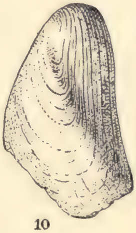
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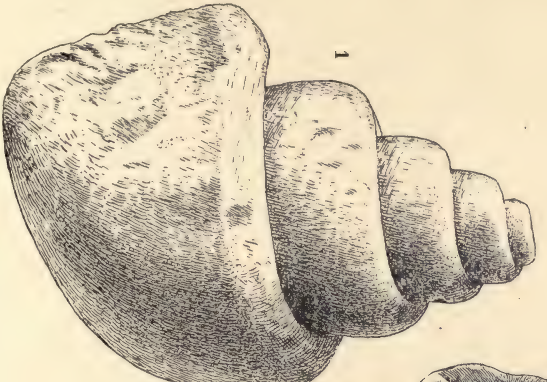
Invertebrates of the Trinity Division—Hill.

PLATE VI.

FIGURE 1.—Cast of Buccinopsis (?) parryi Conrad, showing spire.
FIGURE 2.—Tylostoma pedernalis (Roemer). Distorted specimen.



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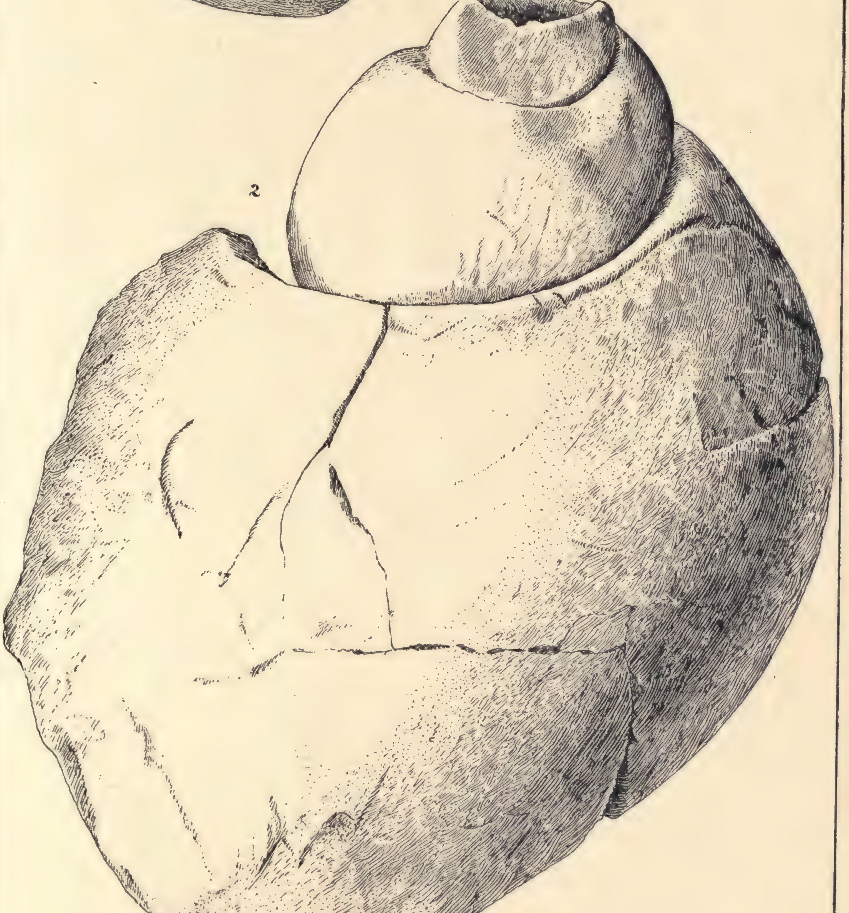

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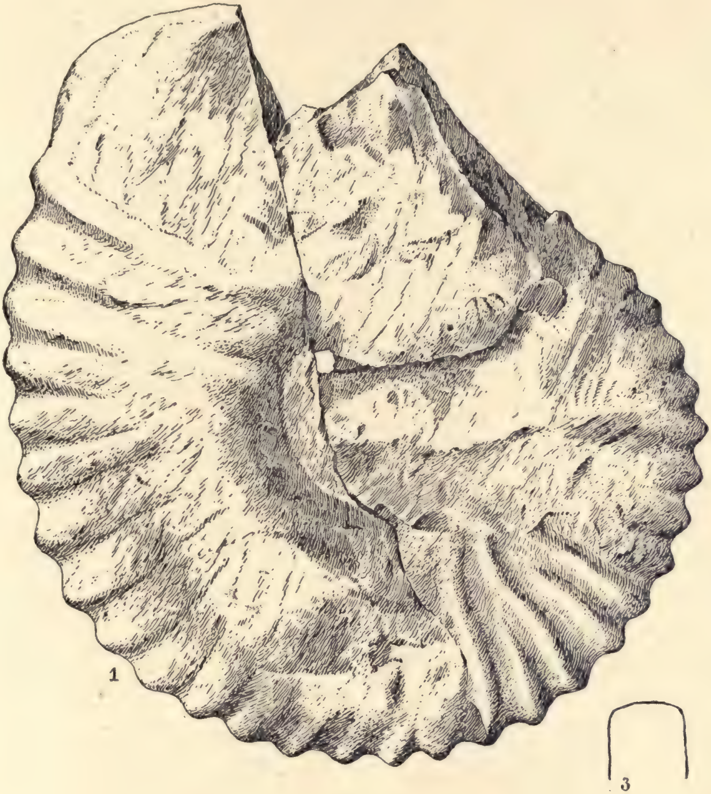
Invertebrates of the Trinity Division—Hill.

Plate VII.

Figures 1 and 2.—Acanthoceras (?) justinæ sp. nov.



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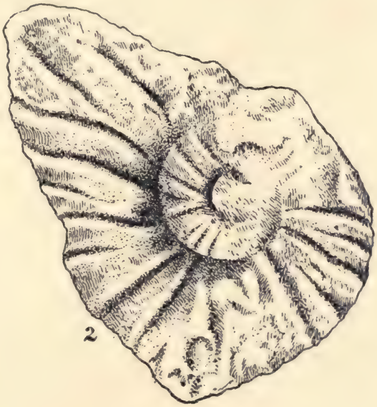

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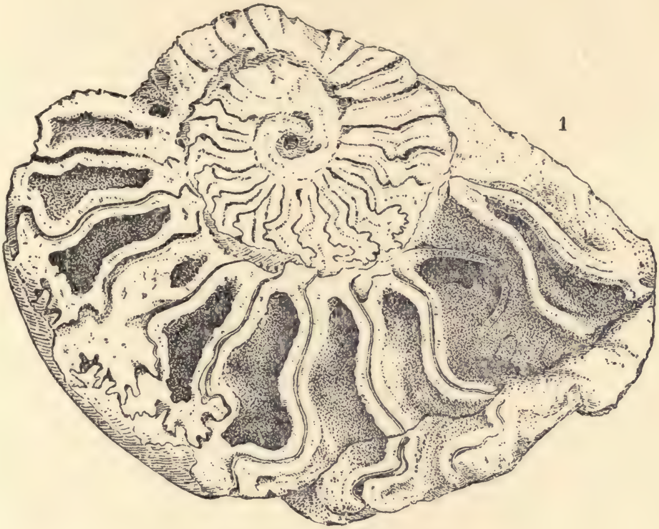
INVERTEBRATES OF THE TRINITY DIVISION—HILL.

PLATE VIII.

FIGURES 1–3.—Neumayria walcotti Hill.



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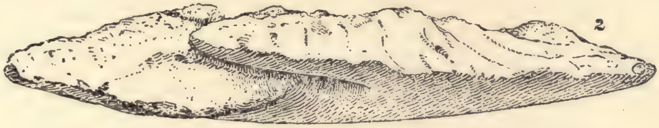

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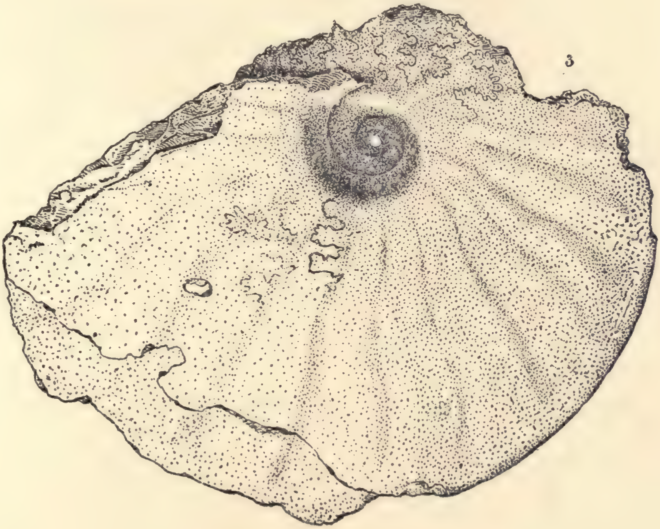

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Invertebrates of the Trinity Division—Hill.

VOL. VIII, PP. 41-54, PL. IX JUNE 20, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

FURTHER NOTES ON YUCCA INSECTS AND YUCCA POLLINATION.*

BY C. V. RILEY, PH. D.

PRONUBA MACULATA.

Since the presentation, a year ago, of the communication on "Some Interrelations of Plants and Insects," in which I summarized what was then known of Yucca pollination and the Yucca moths, some further interesting observations have been made, and the facts which I have to present to-night should be looked upon as additional to those set forth in the previous paper (vol. VII, pp. 81–104). On account of the singular structure of *Yucca whipplei*, which was known to be pollinated by *Pronuba maculata*, I was quite anxious to obtain the facts in reference to this species. The long stamens, the sticky and abundant pollen, and the peltate stigma, with its long hyaline papillæ, are characters which would seem to facilitate ordinary pollination, though the restricted style would render this more difficult, and the peculiarities of *Pronuba maculata*, with its modified tongue, and maxillary tentacles very long and attenuated at tip, were, I felt quite sure, special adaptations to fit it for its work. This Yucca is not only one of the most interesting from the structure of its flower, but is one of the noblest of the cespitose species and placed in the subgenus Hesperoyucca. The flowers are borne in immense panicles on a stalk which arises directly from a crown of leaves near the ground and reaches sometimes a height of twelve feet or more, and I present herewith a photograph which very well illustrates the magnificence of some of the larger specimens (pl. IX). At my request Mr. D. W. Coquillett, of Los Angeles, California, made some special observations last year on the pollination of this species, and on the 12th of June he was able to witness the operations both of oviposition and pollination on a plant while yet the sun was shining brightly, about forty minutes before setting. The act of oviposition does not differ in any particular from that which I have already described in detail for *Pronuba yuccasella*. The pollen is deliberately gathered, and a mass nearly half the size of the insect's head is held under her neck by the coiled tentacles. In pollinating, the tentacles are uncoiled and stretched so that the tips may be inserted into the upper part of the stigma. Mr. Coquillett describes the process of thus pollinating the stigma as lasting about half a minute, after which the insect that he watched descended the ovary and at once mounted to the top of one of the stamens. Here, with her tentacles, she removed both pollen masses (moving her head from side to side during the operation) and added the pollen thus gathered to the mass which she was already carrying. She went to two other stamens in succession, gathering a pollen mass from each. Mr. Coquillett, in communicating his observations, remarks that "it was indeed surprising to witness the evident intelligence which this insect displayed in all her actions wherever the pistil of the flower became pollinated solely through her own labors, and that she went through these maneuvers with the evident intention of pollinating the flower appears to admit of no doubt."

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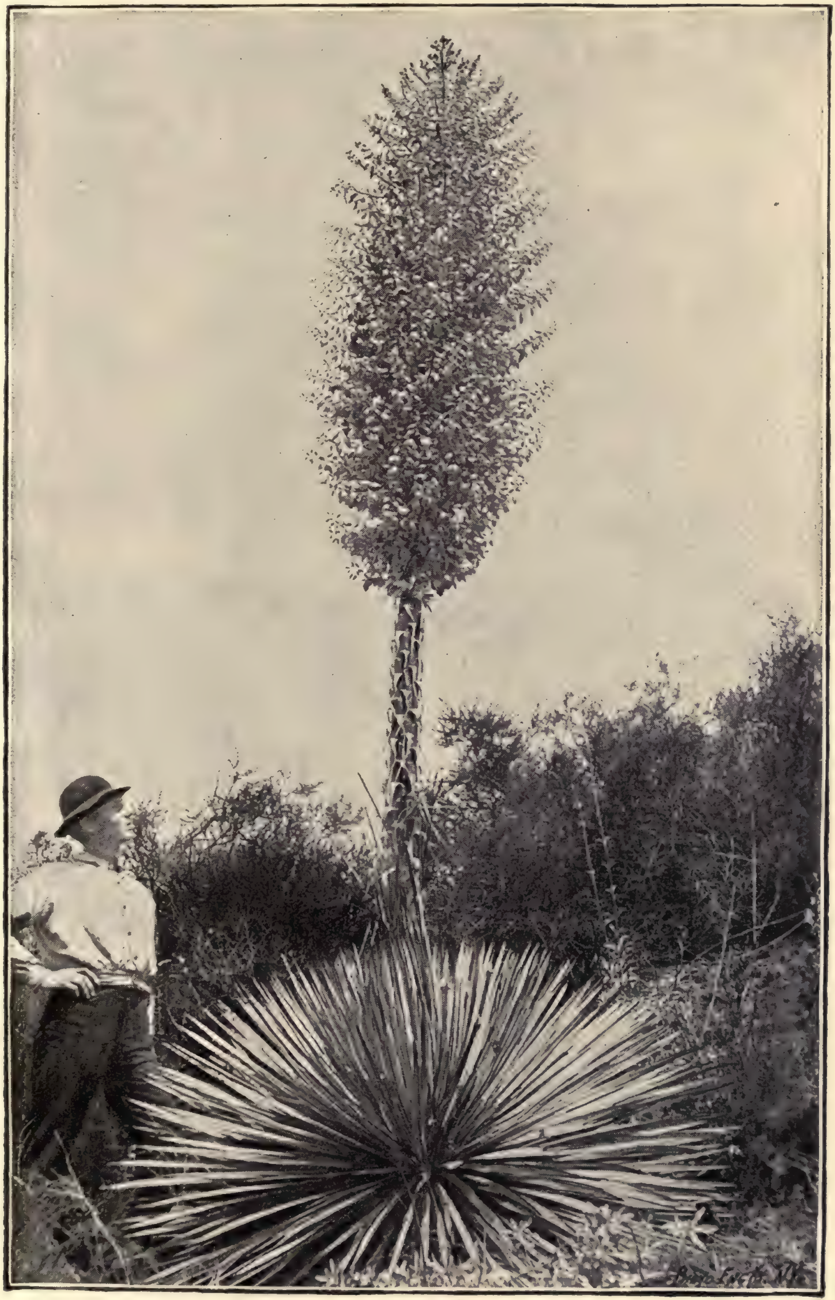
* Presented at a meeting of the Biological Society of Washington, May, 1893.

A number of insects have been observed associated with the flowers of *Yucca whipplei*, but none of them as observed by Mr. Coquillett acted in any way to produce pollination, either intentionally or by accident. As a check to prove the influence of Pronuba on the production of fruit, I desired Mr. Coquillett to enclose another panicle and exclude the moths. We were both somewhat surprised at the result, namely, that a certain number of the pods set on this panicle, and this would prove that (so far as a single experiment justifies conclusion) the species is capable of a certain amount of self-fertilization.



Yucca whipplei.

So far as they go, Mr. Coquillett's observations on the actions of *Pronuba maculata* agree very well with those of Professor William Trelease, who made a special trip through the southwest in the spring of 1892 with a view of studying the pollination of those Yuccas which had not hitherto been studied in this connection. He has published a most interesting article in the Fourth Annual Report of the Missouri Botanical Garden, entitled " Further Studies of Yuccas and their Pollination." This is, in fact, a most valuable contribution to our knowledge of the subject, and is complementary and additional to my own paper published in the annual report of the same series for the previous year. Mr. Trelease's life studies of *Y. whipplei* have added materially to our understanding of its floral characteristics. The anther cells on dehiscing contract so as to expose the pollen freely, but the contents of each cell forms a " rather consistent, two-lobed moist mass, which is held by its lower part but protrudes prominently from the open anther." The ovary is free from the longitudinal depressions which in the other Yuccas usually correspond with the appressed stamens. The capitate stigma is slightly indented at the center " and covered with long, hyaline, delicate papillæ which are always moist with abundant secretion that at length becomes almost gelatinous over the middle of the stigma." He found the nectar apparatus well developed, the septal glands, though narrow, reaching commonly to the base of the ovary, with a conducting groove of corresponding size. The glands are, also, though smaller, more active than in most other species of Yucca studied by him. Professor Trelease also notes that the characteristics of this flower would seem to make it easily self-fertilizable, and remarks on the exceptional occurrence in the lower part of the Cajon Pass of a few plants with more or less abundant, partly developed, but unusually diminutive capsules, in which no evidences of Pronuba action were to be found; and this, added to the experiment made by Mr. Coquillett, would seem to indicate that where Pronuba is absent *whipplei* has the same exceptionally limited power of fructification, whether by self-pollination or pollination by other agents, that we know to be possessed by *aloifolia* among the true Yuccas. Recognizing this possibility, Professor Trelease was somewhat surprised to find that, with the single exception which he noted, no fruit, among all his observations, was discovered which did not clearly show the work of Pronuba.

From his account, as well as that of Mr. Coquillett, it appears evident that *Pronuba maculata*, in accordance with the greater tendency of the flowers of *whipplei* to open during the day, is more diurnal in habit than *Pronuba yuccasella*, carrying on the acts of oviposition and pollination during the day. Further, unlike the other Pronubas so far known, this species rests with the head toward the stigma, and when disturbed is very apt to drop suddenly from the flower and take wing. I cannot do better than quote verbatim Mr. Trelease's interesting account of the act of pollination, that of oviposition being, as already stated, absolutely the same as in *yuccasella:*

> "Having withdrawn the oviduct, in doing which she moves up so that her head is about level with the stigma, or even before this organ is entirely freed, the moth usually proceeds to pollination; but it is not infrequent for two eggs to be laid between each two visits to the stigma, and, owing to her peculiar alertness, she appears to be even more easily frightened into omitting pollination than are the other species of Pronuba. Standing with her head at about the height of the stigma, with the short tongue projecting out in front, she uncoils her long tentacles from the compact mass of pollinia, which she carries similarly to the other Pronubas, only that small part of her burden which adheres to the bases of the tentacles being removed from it, and, raising her body on tiptoe, she very slowly saws the tentacles back and forth across the top of the stigma, generally following one of the three shallow grooves, and very carefully working their slender tips into the more or less gummy exudation over the central depression. Sometimes the operation is interrupted long enough to admit of the tentacles being coiled back against the load of pollen and again extended; but the curious manner in which her head is held back from the stigma, as a rule, prevents any of the main load from reaching even the marginal papillæ.
>
> "On first witnessing this operation I was impressed by the much slower motion of the moth than usual and the evident care which she took to run the ends of the tentacles into the central depression of the stigma, which I then supposed to be solid. The subsequent discovery of the stylar canal, communicating with the ovarian cells, showed that it is into this narrow passage that she so carefully guides the tips of her tentacles with their modicum of pollen, and no doubt the abundant stigmatic secretion serves not only to foster the development of the nascent pollen tubes after pollination, but, wetting the tentacles, aids in the disintegration of her mass of pollinia. These, if really related to her work, would seem to have acquired their coherent structure as a means of facilitating their collection rather than as an adaptation to their removal bodily from the anther to the stigma, as is the case in orchids and asclepiads, where, however, special means of secure attachment to the insect accompany this aggregation of the pollen grains into a large mass."

A further interesting fact connected with the pollination of this species is that Professor Trelease discovered a purely black variety (which he describes as *aterrima*) of *Pronuba maculata* connected with the variety *graminifolia* (Wood) of *Yucca whipplei*, common in San Bernardino county. The actions of this black variety are similar to those of the typical form, and it is also diurnal rather than nocturnal in its movements. The method of gathering the pollen mass is thus described:

> "Flying into a flower, the moth runs about the bases of the stamens after the manner of other species, then quickly clambers upon the inner side of a filament, and, with the tentacles extended over the pollinia, drags first one and then the other out of the anther cells, pressing them together under the throat, and subsequently compacting the mass together, much as *yuccasella* does the powdery pollen of other Yuccas, so that the ball finally consists of as many as ten or a dozen pollinia. So quick and energetic are the motions by which the pollinia are removed that the stamens are often shaken quite violently, as I have before noted in the more nervous attempts of *yuccasella*."

PRONUBA YUCCASELLA ON THE PACIFIC COAST.

Of the fleshy fruited Yuccas Professor Trelease was able to study, among others, *Yucca baccata* Torrey, which is pollinized by *Pronuba yuccasella.* While he was not able to observe the acts of pollination, all the circumstances and the facts which he obtained would indicate that it is precisely the same as described for other species of Yucca that are fertilized by this moth, and the fertilized flowers show "conclusively that the pollen is thrust well into the stigmatal canal," or in some cases apparently even into "the top of the ovarian cells, which, owing to the short style and the deep stigmatic notches, they [the moths] can reach easily with their long maxillary tentacles." The moths taken from flowers at Cabazon and San Diego are somewhat above the average in size, with the horny and chitinous parts somewhat darker than in the typical form, but specimens which he sent me cannot be considered to have even varietal differences, and find their counterparts in my cabinet in specimens from Dakota and Colorado.

Yucca rupicola Scheele, of southern Texas, and *Y. elata* Engelm., extending from southern Texas to southern Arizona, are both pollinated by *Pronuba yuccasella*, as Professor Trelease ascertained.

PRONUBA SYNTHETICA.

Mr. Trelease was also fortunate enough to be able to study the operations of *Pronuba synthetica* on the flowers of *Yucca brevifolia.* This Pronuba is slower in its movements and slower to take flight than the other species observed, though he found it more active during the day than is *Pronuba yuccasella.* It takes wing less readily and then merely sails down to the ground. This indisposition to leave the flower may be connected with the almost constant high winds on the Mojave desert, where this Yucca most abounds. The fertilized pistils of this Yucca are quite noticeable, by comparison with those of other species, by their symmetry and lack of constriction or indentation so uniformly present in the Yuccas that are punctured by *Pronuba yuccasella* and *P. maculata.* The explanation is found in the fact that *Pronuba synthetica* pierces "the uppermost part of the style, conveying its eggs down to the ovary through the stylar channel, the course followed by the pollen tubes." This fact interested me very much, for I recollected very well in my first studies of *Pronuba yuccasella*, before the act of oviposition had been witnessed, that, puncturing for the purpose of oviposition being unrecorded and therefore quite exceptional among Lepidoptera, I was strongly of the opinion that the egg would be thrust through the stigmatic opening down the stylar channel. The instinct to oviposit only on the youngest flowers is particularly marked in *synthetica*, which Trelease frequently saw forcing itself into the narrow clefts between the rigid sepals of the opening bud, the flattened form of the insect facilitating the operation. This habit also suggests the cause of the looseness of the wing scales and the ease with which they are lost. Mr. Trelease's observations in detail on the actions of this Pronuba cannot well be condensed, and I quote them entire:

"When about to deposit an egg, having selected a suitable flower, the female of *synthetica* runs to the bottom of the stamens much as *yuccasella* does, makes a rapid, more or less complete circuit of their bases, and then quickly ascends to the very top of the pistil, her thorax rather higher than the end of the stigma, and with her short but strong ovipositor cuts through the thin wall, into the stylar channel, rarely as much as 2 mm. below the tip of the stigma, meantime holding fast to the pistil, the stamens being below her reach. The long extensile oviduct is then passed through the puncture, the egg being laid apparently within the ovarian cell, along the funicular end of the ovules. In removing the oviduct the moth not infrequently carries her body across the stigma, so that at first sight she appears to be withdrawing it directly from the mouth of the stylar canal; but I have never seen her make direct use of this canal. The operation consumes more time than does the oviposition of either *yuccasella* or *maculata* as I have observed them, and usually takes altogether from two and a half to three minutes. Sometimes two or more eggs are laid before the stigma is pollinated, but commonly after laying each egg the moth retreats to the bottom of the flower and then again ascends the pistil until her head is brought even with the stigma, when she uncoils the large tentacles from their resting-place against her load of pollen and passes them back and forth in the stigmatic chamber, with almost the same motion as the eastern species, usually making use of one of the stigmatic notches. While so employed she carries the rather short tongue almost straight out above the stigma, but I have never seen her make any use of it to force pollen into the latter, nor has she been observed to attempt to feed on the slight stigmatic secretion, nor to search for food at the base of the flower, where, if anywhere, the nectar of the septal glands should be found."

Professor Trelease has not yet published anything upon the other species of Yucca insects which he collected, and I take this occasion to present some few unrecorded facts in reference to some of the species of Prodoxus which he was kind enough to send me, as also some additional data from other sources.

THE SPECIES OF PRODOXUS.

Prodoxus coloradensis.—This was described by me from a single male taken in 1884 by Mr. H. K. Morrison in Colorado. In April, 1892, Mr. F. V. Coville, the present botanist of the Department of Agriculture, gave me a few small pieces of the flower-stem of a Yucca infested by a Prodoxus larva. The plant was collected in the Charleston mountains, Lincoln county, Nevada, the previous February, and was undoubtedly *Yucca baccata*. From these pieces of stem I reared early in the present month two imagos which proved to be *Prodoxus coloradensis*.

I have also received from Professor Trelease four other collected specimens, rather battered and imperfect, which belong to this species, all taken from the flowers of *Yucca baccata* at Banning, California. These two bred specimens are constant and agree thoroughly well with the type, except that there is no inclination to pale yellowish in the white scales of the head, and the thorax shows some black scales on the tegulæ, a line of black around the collar, and, in one of the specimens, along the middle of the thorax; characters not noticeable except in well-preserved specimens. The white portion of the antennæ extends also in these two specimens beyond the basal third and fully to one-half the length of the organ. The four collected specimens from Professor Trelease indicate considerable variation; in one specimen the outer arm of the transverse Y-band across the posterior portion of the wing being absent, while in another it is broken, as is also the basal portion of the median band. The same is true of the band across the middle of the wing, while the upper portion of this band is connected with the basal band. The larva shows no striking characteristics, but is very similar to most other Prodoxid larvæ, being uniformly yellowish-white, the head and cervical shield anteriorly slightly darker, the ocelli black, and the mandibles brown and three-toothed.

Prodoxus reticulatus.—One of the specimens received from Trelease taken in flowers of *Yucca whipplei*, variety *graminifolia*, at Arrowhead Springs, in California, would indicate that this species, which I described from three females from Los Angeles county, California, and the habits of which were not known, breeds in some part of this Yucca. The single female sent by Trelease is interesting in that it shows some variation in the direction of *coloradensis*, especially by the separation of the basal half of the W-shaped band.

Prodoxus cinereus.—A section of the flower-stem of *Yucca whipplei* sent me by Mr. Coquillett last July contained a number of different larvæ, and among them most numerously one which subsequently proved to be the larva of *Prodoxus cinereus.* We have known that this species breeds in the main stem of this Yucca, but none of the early states had been observed. The larva is remarkable in that it differs materially from the typical Prodoxus larva. It is, first of all, very much more elongate, with the sutures between the segments more strongly impressed. It is, further, more uniform in diameter than the typical Prodoxus larva; but the most striking feature is the anal segment, which bears on its ventral plate two stout, brown, decurved horns resembling those of the larva of Trogosita in Coleoptera, except that these are curved in the opposite direction. I add a technical description:

PRODOXUS CINEREUS. *Larva.*—Average length when full grown, 8.25 mm.; body elongate, but slightly curved, the joints moniliform; head rather large, more horizontal, and more free than in other species, light brown in color, darker anteriorly; borders of clypeus almost white; pigment spot around ocelli, and the mandibles dark brown; the Y-shaped lines distinct and having exactly the outline of a rather narrow wine glass; cervical shield pale, but fuscous around the borders and especially at the middle of the anterior border; sinuate laterally and cleft posteriorly by the pale mesial line; characteristic feature a pair of decurved, dark, horny anal hooks, situated on the ventral apex; anal plate but faintly chitinous and with a fuscous mark upon it; a sub-ventral depressed line but faintly indicated and more highly polished than the rest of the surface; spiracles extremely small, with a faint yellow annulus, the prothoracic pair situated on the sub-ventral depressed line, the others much higher up on the anterior third of the segments; no thoracic legs, but slight tubercles in place of them; general color faint bluish-green or yellowish-green, losing color, however, in alcohol.

Pupa.—Offering no peculiar structures, but presenting the characteristics of the other species of the genus; skin very delicate; the cephalic projection not very prominent and the anal tip absolutely smooth; dorsal spinules reduced almost to obsolescence. The shrunken larva skin with its two strong hooks remains attached to the tip of the body of the pupa, and doubtless serves to hold it secure when it pushes from the surface of the thin epidermis to give forth the imago.

The imagos issued from the 11th of April to the 8th of May, the antennal sheaths and leg sheaths of the pupa separating, the former curling very much, as in other Lepidopterous pupæ which have wood- or pith-boring larvæ.

Prodoxus æenescens.—Professor Trelease has sent me a full account of the oviposition of this species upon *Yucca whipplei*, and it corresponds in every particular with the oviposition of *Prodoxus decipiens* in the East. In this case the species is not confined to one or the other of the forms of *whipplei*, but occurs on both the typical form and the variety *graminifolia.*

Prodoxus intermedius.—This species was described from two female specimens taken in Texas and one taken in Colorado, in 1887. It is a most interesting form, bearing an even more deceptive resemblance to *Pronuba yuccasella* than does the much commoner *Prodoxus decipiens.* For though the female lacks the remarkable maxillary tentacles of Pronuba, the ovipositor is long and delicate, very much as in the latter species. I have been anxious, since publishing the original description, to obtain a male of this rather puzzling species, and, fortunately, Professor Trelease sent me specimens associated with the females. On a superficial examination the males of this species would be separated with great difficulty from the males of *Pronuba yuccasella;* but upon denuding the genitalia the differences at once appear, and it is curious to note that while the form of the genitalia, though showing slight variation, corresponds with that of *Prodoxus decipiens*, yet the claspers agree more nearly with those of *Pronuba yuccasella*, in having but the one large tubercle.

Prodoxus intricatus sp. nov.—I recently received from Mr. J. T. Mason, who has been kind enough to observe and collect some of the Yucca insects for me, a number of specimens of a Prodoxus which he found in the flowers of one of the tree Yuccas in Jalapa, Mexico. He sent also flowers and sections of one of the leaves of the Yucca, which, from this material, appears to be, without much doubt, *Yucca guatemalensis.* The moths were found abundantly in the flowers, but unfortunately reached me in rather dilapidated condition. The species is of the same general size as *Prodoxus reticulatus*, and with a somewhat similar but more varied and less distinct maculation. It is, however, a much darker species. I would simply characterize the species here, by comparison with *reticulatus*, with a view of adding one more link in our knowledge of the Prodoxids associated with the different species of Yucca.

In size and general appearance most nearly related to *P. reticulatus*, the general color, however, more sordid, the lighter shades inclining to pale fulvous, with a slightly golden sheen. Primaries more acuminate at apex, and marked with black scales, taking on, in a very general and indefinite way, the pattern of those of *reticulatus.* Secondaries also more acuminate at tip and blacker. Fringes of all wings black. Under surfaces fuliginous, with the faintest trace of pale marks on the costa of primaries. Anal claspers of male short, recurved upward, with a rather angular production on the inferior margin, and with three minute, but distinct, black teeth. There is also a similar black tooth on the inner margin near the tip. Ovipositor of female similar to that of *reticulatus.*

Some of the darker specimens present an almost black appearance, the black marks inclosing narrowed, luteous spaces, which appear like so many spots.

Described from 20 males and 5 females, none of them in perfect condition.

CONCLUSIONS.

The additional facts which I have thus presented upon this subject of Yucca insects and Yucca pollination serve to confirm the generalizations which I have already indulged in. So far as variation is concerned they add still further links to the chain of alliances between the different forms of this interesting family, Prodoxidæ. The black form of *Pronuba maculata* presents us with the question of varietal or specific value that has arisen with the plant itself upon which it occurs, so far as regards the variety *graminifolia* of *Yucca whipplei.* Most specialists would be inclined, without any intermediate specimens, to characterize this black form as a distinct species, especially as it is dissociated from the other more typical forms and confined to one particular variety of Yucca. Yet in every other character but color it agrees precisely with the typical *maculata*, and I am strengthened in my view of considering it a mere variety by the well-known variation in the maculation of the typical species. It is a form that is differentiated as to color without having yet acquired any essential structural differences, though it may have lost the power to intercross with the typical form. Here, also, the color must be looked upon as of secondary importance to the species, and more or less fortuitous, as it is difficult to see what advantage the purely black has over the maculate form, especially in an insect essentially diurnal.

So it is in the variation of the banded species of Prodoxus. Some of the specimens combine the characters of at least two different species, without being referable to either, satisfactorily, and in the present state of our knowledge most entomologists would be justified in describing them as distinct species; but there can be little doubt that, when abundant material from different localities is obtained, all these transversely-marked forms will be difficult to separate. Such, however, is the case in almost every genus, whether of plants or animals, and the Prodoxids simply furnish us with a rather marked illustration of the fact that the variation has gone on and is going on, so far as purely colorational characters are concerned, without any very definite and unchangeable differences having yet been acquired. How strikingly such facts compare with the permanency, even in colorational characters, of such well-established species in the same order as the cosmopolitan *Vanessa cardui*, which, with a most beautiful wing design and a most complex colorational pattern on the inferior surfaces, remains essentially constant in all its details in all parts of the world where it is known.

The decurved hooks in the larva of *Prodoxus cinereus* are also most interesting from an evolutional point of view. Such anal hooks are extremely rare in Lepidopterous larvæ, being found in only a very few pith-boring or stem-boring species.* We have in this structure, which is so exceptional in Lepidoptera, another illustration of a principle to which I have often referred in my writings, namely, that larval structure in insects has been modified independently of the ultimate structure, and is, as a consequence, of very little taxonomic value. Thus we have in this same family the larvæ of Prodoxus, (e. g., the typical *decipiens*) which remain in their short burrows, possessing no legs, while those of Pronuba, which quit their burrows and penetrate the ground, possess thoracic legs. Yet in the particular case of *Prodoxus cinereus* the larva approaches Pronuba in having thoracic tubercles which may be looked upon as either remnants of legs or the beginnings of the development of such. This larva burrows in the soft pith of *Yucca whipplei* much more freely than any of the other species of the genus so far studied, making much longer channels, the substance of the stem being less firm than that of the other species of Yucca. In so far, therefore, as this particular Prodoxus larva has peculiar structures, we can trace their origin to purely dynamic influences, assisted by heredity and selection—a consequence, in other words, of environment—and repeated independently in larvæ of different orders having no possible genetic connection.

The distribution of the genus Pronuba, as exemplified in these additional observations, is extremely interesting. *Pronuba yuccasella*, the typical species of the genus, not only occurs over

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*I have not had time to closely scan the literature for cases of this kind, but do not recall any. I am familiar, however, with three unrecorded instances, two of them of Pterophorid larvæ which bore the stems of Solidago. One is the larva of *Alucita kellicottii* Fish, which singularly departs from the typical Lepidopterous larva in its elongated body and in having a pair of supra-anal spines which give the anal plate an appearance so characteristic of that of many Coleopterous larvæ. The second case is that of an undescribed species of the same family, Pterophoridæ, which has the anal plate obliquely truncate and fringed with a row of stiff hairs and with a pair of small thorns at its ventral border, this modification also recalling that possessed by several wood-boring Coleopterous larvæ. The third case is that of the larva of a Noctuid, *Hadena stipata* Morr., which burrows in the pith of young corn or maize. It has the anal plate obliquely truncate and flattened along the posterior margin, which is armed with a series of horny points, and thus again repeats the structure which recurs in certain Coleopterous larvæ, especially of the Elateridæ, which inhabit burrows in the trunks of trees.

half the continent, as I have previously shown, but extends to the Pacific coast and is found as far south as San Diego, showing over this wide range absolutely no differences that would justify varietal designation. All the characters are absolutely the same, and the rather dark coloring of the horny and chitinous parts of the body in the California, Dakota, and Colorado specimens would indicate that the western forms have this peculiarity as compared with the eastern. This species is now known to pollinize all the true Yuccas so far studied, and accompanies them across the continent. It thus pollinizes *Yucca filamentosa* and its several forms in the northeast; *Y. gloriosa* and *Y. aloifolia* in the southeast; *Y. angustifolia* (*glauca*) in the Rocky Mountain regions; *Y. rupicola* and *Y. elata* in the southwest; and *Y. baccata*, which connects the territory of *Y. angustifolia* with that of *Y. brevifolia* and *Y. whipplei*. It thus occurs in the same territory as its two congeners, *Pronuba synthetica* and *P. maculata*, with its *aterrima* variety, while these last are restricted to their respective Yuccas. This fact, as Professor Trelease has pointed out, strengthens the inference that *brevifolia* and *whipplei* are primary Pacific coast types, while *baccata* is an immigrant from the east. It remains yet to observe the pollinizers associated with *Yucca filifera*, *Y. australis*, *Y. treculeana*, and *Y. guatemalensis*, each of which will probably have a distinct Pronuba, while the other Yuccas not enumerated here will probably not have distinct species connected with them.

It would carry me too far to speculate further on the additional facts brought forth, but I would urge in conclusion that in all Mr. Trelease's interesting observations in his special studies of these different species of Yucca, and after having paid particular attention to the point, he has failed to see a single Pronuba in any species attempt to feed on either the stigmatic secretion or the septal nectar. He was also unable to convince himself that in any case the insect makes use of the tongue in pollination, as he once thought it might. In this and other respects he fully confirms the conclusions which I have drawn in my previous communication to the Society, while the additional data which I have indicated give further force to my remarks upon variation, as exemplified by these Prodoxids.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTION OF A NEW WHITE-FOOTED MOUSE FROM THE EASTERN UNITED STATES.

BY GERRIT S. MILLER, JR.

A critical study of over five hundred specimens of Sitomys collected in the northeastern United States and adjoining British provinces leads me to the conclusion that two distinct though somewhat closely related animals are at present confused under the name of *Sitomys americanus.* The two forms may be distinguished by the following diagnoses:

Ratio of tail vertebræ to total length ranging from 40 to 47.9; pencil, 2 mm. to 5 mm.; tail often not sharply bicolor; young usually passing directly from the plumbeous first coat to the russet-brown pelage of the adult, which is thus present in the great majority of specimens. . . . . *americanus.*

Ratio of tail vertebræ to total length ranging from 46.5 to 53.6; pencil, 4.4 mm. to 11 mm.; tail always sharply bicolor; young always passing through a gray phase between the plumbeous first coat and dull yellowish brown pelage of adult, which is thus comparatively seldom met with. . . . *canadensis.*

Sitomys americanus canadensis subsp. nov.

Hesperomys myoides Baird. Mam. N. Am., 1857, 472 (probably in part only), not *Cricetus myoides* Gapper.

Subsp. Ch. Somewhat larger than *Sitomys americanus* (Kerr), with longer, more hairy tail, and duller, less russet coloration;

young always passing through a gray phase before assuming the fulvous pelage; tail always sharply bicolor.

Adult (♀ No. $\frac{1612}{1409}$, collection of G. S. Miller, Jr., Peterboro, Madison county, N. Y., July 24, 1892); length, 200*; tail vertebræ, 100; pencil, 6.6; hind foot, 21.4; ear from notch, 19; ratio of tail vertebræ to total length, 50. Fur everywhere except on lips and chin, slaty plumbeous at base. Dorsal surface wood-brown, slightly tinged with yellow, and very sparsely sprinkled with blackish hairs, which form a faint, ill-defined dorsal stripe; area between ears somewhat grayer; ears thinly clothed with whitish hairs internally, externally with brown; a whitish tuft at anterior base of ear; whiskers reaching about to shoulders, mixed blackish and silvery; tail sharply bicolor, white ventrally and at extreme tip, Vandyke brown above; dorsum of manus and pes, together with whole ventral surface, soiled white.

Young in gray phase (♀ No. $\frac{1638}{1435}$, collection of G. S. Miller, Jr., Peterboro, Madison county, N. Y., August 1, 1892); length, 201; tail vertebræ, 105; pencil, 11; hind foot, 21; ear from notch, 17.8; ratio of tail vertebræ to total length, 52.2; contained three embryos. Color of dorsal surface intermediate between broccoli-brown and smoke gray, with a slight admixture of blackish hairs as in adult, and a very faint trace of a narrow yellowish line bordering white of belly; a clear smoke-gray area between ears; otherwise colored like adult, except that the dorsal stripe on the tail is somewhat darker.

On comparing over one hundred specimens of *Sitomys americanus canadensis* with about four hundred skins of *S. americanus* the longer, more hairy tails and, as a whole, grayer color of the former are very noticeable. Three "stages of development" may conveniently be recognized in these mammals: first, the plumbeous young; second, fully grown and sexually mature individuals with the teeth still unworn, and, third, old animals with worn teeth. In the first stage there is nothing to distinguish the two subspecies except the longer, more hairy tail of *S. canadensis.* Specimens in the second stage differ most markedly, as *S. canadensis* is now gray, while *S. americanus* has, for the most part, assumed the russet coat. In the third stage again the two forms resemble each other somewhat closely, since both are now in the fulvous pelage; *canadensis*, however, may always be distinguished from its smaller relative by its longer, more hairy, and more sharply bicolored tail and paler, grayish yellow color, without trace of the russet usually seen in *americanus*, and much less distinct dorsal stripe.

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* All measurements are in millimeters, unless otherwise specified.

The differences in color characterizing these two animals are rather difficult to describe, but nevertheless they are of such a kind as to appeal immediately to the eye, especially when specimens in the flesh are examined. In many adults of *S. canadensis* the color of the dorsal surface is nearly homogeneous yellowish-brown or grayish-brown throughout, with merely the faintest possible trace of darkening in the mid-dorsal region. There is usually an indication of a very narrow yellowish line separating the color of the sides from the white of the belly. This is apt to be more distinct in the region of the cheeks and neck. The white ventral surface has frequently a soiled yellowish cast, which is oftenest met with in mid-summer. The pencil is usually white, and this color frequently involves the whole tip of the tail, sometimes for a distance of 30 mm., a feature very rarely seen in the shorter-tailed *S. americanus.* Grayish examples of *americanus* are sometimes met with among specimens taken in the summer, but with the exception of these very few of the smaller race approach in color even the brightest individuals of *S. canadensis.* In the gray phase *Sitomys americanus canadensis* bears a somewhat close resemblance to *S. americanus arcticus* (Mearns), the type of which in the Museum of Comparative Zoölogy at Cambridge, Mass., I have examined. The former may, however, be at once distinguished by its much longer tail, proportionally longer than in *americanus*, instead of proportionally somewhat shorter, as is the case with *arcticus.*

So far as I can see, *Sitomys americanus canadensis* shows no cranial or dental characters to separate it from its near allies.

As in all members of the genus, there is here considerable variation in actual size as well as in proportions. This variation for each form (*americanus* and *canadensis*) proves to be much less than recent writers have generally accredited to "*Hesperomys leucopus.*" Both Allen (Bull. M. C. Z., I, 1869, 227, 228) and Coues (Monog. N. Am. Rod., 1877, 53) allow a large range of variability in the ratio of tail vertebræ to total length. Nevertheless, this character proves to be sufficiently constant to be of considerable diagnostic value. Mr. Allen says (l. c., pp. 227–228): "But the most variable character consists in the relative length * * * of the caudal vertebræ. About one-fifth of the Massachusetts specimens (of "*H. leucopus*") have the tail vertebræ equal to or longer than the head and body. * * * At least four-fifths, however, have the tail shorter than the head and body, and occasionally one occurs with the tail only equal to the body alone. In these latter the proportional length of the tail vertebræ to the length of the head and body is as 68 to 100; in the other extreme, or in those with long tails, as 118 to 100. The variation between these extremes is hence fifty per cent. of the mean—a striking example of the unreliability of this character as a specific distinction. * * *"

Dr. Coues repeats Mr. Allen's observations, adding: "The variation in absolute and relative length of the tail is greater than in any other dimension. * * * But this ceases to be remarkable when we recollect that it is purely a matter of what has been aptly called 'vegetative repetition.' It seems to be a well-nigh universal law that those parts or organs that are least specialized—*i. e.*, those of which several have the same or corresponding character and function—are liable to be produced with a high degree of irregularity as regard their number, and the more such there are the wider are the limits of variation apt to be. In this species, one of our longest-tailed rodents, the law is perfectly illustrated."

A glance at the appended tables of measurements and ratios of two hundred and fifty white-footed mice from the eastern United States and adjoining British provinces will show the incorrectness of the views quoted above. The range of variation in ratio of tail vertebræ to total length is in *S. americanus* from about 40 to about 48, while in the longer-tailed *S. a. canadensis* the variation is from 47.4 to 54.2. That Dr. Coues and Mr. Allen should have fallen into this error is probably due to the fact that their measurements were taken in part from distorted skins or alcoholic specimens, and also to the confusion of the two races under one name. The measurements here tabulated were all taken from the fresh specimens before skinning, and, unless otherwise stated, the writer is responsible for their accuracy.

So many names have been proposed for white-footed mice from eastern North America that it may appear somewhat hazardous to institute still another; hence the species described by authors from the region of importance in the present connection may well be considered here in some detail.

The first is, of course, the *Mus agrarius americanus* Kerr (An. Kingd., I, 1792, 231, based on Pennant, History of Quadrupeds, "No. 302B").* The description given by Pennant makes special reference to the mixed "dusky and ferruginous" color of the back and "orange coloured" sides of his American Field Rat, terms which refer unequivocally to our smaller and better-known animal. Any doubt in the case is dispelled by the addition by Pennant in the Arctic Zoölogy (I, 1784, 131), "length, about four and a half inches; of tail, four inches;" thus showing that it was the short-tailed form that he had in mind.

On Pennant's animal was based also the *Mus sylvaticus noveboracensis* of Fischer (Synopsis Mammalium, 1829, 318), the habitat of which is given as "in Novo Eboraco," and in all probability the *Mus noveboracensis* of Selys Longchamps (Etudes d'-Micromammalogie, 1839, 67), since this author remarks that the animal is a good species, although considered merely a variety by previous writers. That it is clearly the short-tailed animal that Selys Longchamps refers to is shown by the following extracts from the original description: "Son pelage est d'un fauve plus vif sur les côtes de la tête et du corps. * * * Longeur totale, 6 pouces 2 lignes; du corps, 3 pouces 6 lignes; de la queue, 2 pouces 8 lignes." This mouse is said to replace in North America the European *Mus sylvaticus*.

Rafinesque's *Musculus leucopus* (American Monthly Magazine, III, 1818, 446) is named among the ten new species of "wild rats" met with by that prolific describer of species during "a journey through the western region of the United States"—that is, in the Ohio valley and the pine barrens of Kentucky. As there is little chance that the range of *Sitomys canadensis* extends to that region, the name is hardly worth considering here. It may be mentioned, however, that Rafinesque's animal is said to be "fallow above," an expression which might apply fairly well to *S. americanus*, though hardly to the larger form.

The next name to be considered is the *Cricetus myoides* of Gapper (Zoölog. Journ., V, 1830, 204, pl. X). This animal, from the region between York and Lake Simcoe, Canada, is described as having the "upper half of the body mixed black and light reddish or yellowish brown." It is further stated that "it measures 3¾ inches from the tip of the nose to the insertion of the tail; the tail itself, 3¼ inches." Thus color and measurements alike refer to *S. americanus.* Moreover, two white-footed mice kindly sent me in the flesh by Mr. I. R. Bourchier, of Sutton, West Ontario, Canada, just south of Lake Simcoe, are perfectly typical of the smaller form.

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*Synopsis of Quadrupeds, 1771, p. 303, No. 320A (American Field Mouse). History of Quadrupeds, II, 1781, p. 444, No. 302A.

Arvicola emmonsii De Kay, from Massachusetts (in Emmons' Report on the Quadrupeds of Massachusetts) is clearly a synonym of *americanus.* The color is given as simply "brown above, darker along the back than the sides," but the whole length is stated to be 6 inches; tail, 2.5 inches. This animal is said to inhabit "*meadows* and wooded places. It is often seen in *fields recently mowed*, and is known by the name of Deer Mouse" (italics mine). *Sitomys americanus canadensis* never occurs in fields and meadows, where, however, *S. americanus* is often found.

Wagner's *Hesperomys maniculatus* (Wiegmann's Archiv., XI, 1845, Bd. I, 148 *), from the Moravian settlements in Labrador, is described as "supra fuliginoso brunneus * * * Körper 3″ 2‴, Schwanz 2″ 5‴." In Beiträge zur Kentniss der Säugthiere Amerikas (Abhandl. Ak. Wiss. Wien, 1848, 315, 316) the author gives practically the same diagnosis, followed by the remarks: "Gestalt, Grösse und Farbenvertheilung verhält sich wie bei *H. leucopus*, so dass ich nur die Differenzen anzugeben brauche, welche sich zwischen ihr und dem letztern, von dem ich dermalen nur Beschreibungen, und zwar zunächst die Richardson's vergleichen kann, ergeben. Diese Abweichungen bestehen darin, dass bei *H. maniculatus* die Oberseite weit trüber gefärbt ist, indem sie namlich blos russig gelblichbraun und schwarz gesprenkelt ist, ohne Beimischung von Rostroth vie es von *H. leucopus* angegeben wird." This description is somewhat puzzling, and without specimens from the coast of Labrador it is impossible to decide just what animal it refers to. That *S. canadensis* is not Wagner's animal is shown by the measurements, which being taken from "2 Weingeist Examplaren" must be fairly accurate.

Hesperomys campestris Le Conte, from New Jersey, is described so vaguely (Proc. Ac. Nat. Sci. Phila., VI, 1853, 413) that, to use Professor Baird's words (Mam. N. Am., 1857, 485): "Of the affinities of this animal I will hazard no conjecture." That it is not the same as *S. canadensis* is shown by the measurements—length,

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* Not "1843, II, 141, and 1845, II, 148," as given by Baird and Coues.

3.4 inches; tail, 2.7"—which were taken from an alcoholic specimen.

The next name to be examined is the *Hesperomys gracilis* of Le Conte (Proc. Acad. Nat. Sci. Phila., vii, 1855, 442). Le Conte states that the animal "inhabits Michigan; Professor Baird." From the description, "dark slate color above, a little tipped with brown," it seems probable that the type specimen was immature. There are some discrepancies between the measurements given in the original description and those of the same specimen given by Baird (Mam. N. Am., 1857, 473). According to Le Conte, the length (head and body) is 3.8 inches; tail, 4, while Baird gives the dimensions of the same parts as 3.60 and 3.70 inches respectively. The latter author adds that the body is stretched. The long tail of this specimen might suggest the possibility of its being the same as my *canadensis*, but on account of its poor condition and the vagueness of the description, it seems wisest to discard the name entirely as undeterminable. Moreover, Baird states that the pencil of the type is 0.10 in. (2.5 mm.) in length, which is much less than in any specimens of *S. canadensis* that I have seen.

While not wishing to enter here into a general discussion of the relationships of *Mus michiganensis* Aud. and Bach., and *Mus bairdii* Hoy and Kennicott, a few words concerning the probable bearing of these animals on the present case may not be out of place. *Mus michiganensis*, from Erie county, Michigan, is described (Journ. Acad. Nat. Sci. Phila, VIII, pt. ii, 1842, 304) as a "mouse with yellow cheeks, a light grayish-brown color above, whitish below. * * * The feet, nails, ears, and tail are light brown." It is farther remarked that "there is no distinct line of demarkation between the colors of the back and under surface, nor does the white extend along the sides as in the white-footed mouse. Dimensions: length of head and body, 4 inches 0 lines; length of tail, 2 inches 6 lines." That this animal cannot be the same as *S. canadensis* is shown by the short tail and peculiar coloring of the feet and sides.

The description of *Mus bairdii* (Rep. Com. Patents for the year 1856, published in 1857, p. 92) from northern Illinois and southern Wisconsin refers to some short-tailed, bright-colored mouse, quite unlike *Sitomys a. canadensis*, as the following extracts will show: "Length of the adult male, from nose to root of tail, 2⅞ inches; tail (vertebræ), 1⅞ inches; hind foot, ¾ of an inch. Head and body of a large male, 3¾ inches; tail, 2 inches. In another specimen, the head and body $3\frac{3}{16}$ inches; tail, 1¾ inches. In spring the hairs of the upper parts are plumbeous at the base, tipped with ashy and yellowish brown; a few longer hairs, entirely black, interspersed. The tips of most of the hairs deepen into black along the back, giving a broad, black stripe when the hair lies flat. In some specimens this stripe is not so dark as in others, but is quite distinct in all, while in some it is pitch-black." It will be remembered that one of the noticeable color features of *S. canadensis* is the indistinctness-of the dark dorsal stripe; hence *Mus bairdii*, whatever it really may be, is a very different species.

The animal from Burlington, Vermont, described by Baird under the name of *Hesperomys myoides* (Gapper) (Mam. N. Am., 1857, p. 472), is, in part at least, the same as the subject of the present paper. Baird remarks that "all the white-footed mice from near Burlington, Vermont, had much longer tails in proportion than those from Middleboro, Massachusetts." The only specimens, three in number, that I have seen from the locality in question are, however, typical *americanus*. Baird's statement, "tail vertebræ generally .25 of an inch longer than head, and body with a decided pencil at the end," and also table of measurements on page 473, refer, without question, to the long tailed form; but his description leaves a slight doubt as to just what animal he had in hand. I have never seen a specimen of *S. canadensis* in which the color is "more vivid yellowish brown" than in *S. americanus*, nor do any resemble *S. aureolus* in color, as is said to be the case with "*H. myoides*." Baird considered the presence of cheek pouches to be the best diagnostic character of *myoides*. More recently, however, it has been shown by Allen (Bull. M. C. Z., I, 1869, 229) that these structures occur also in the common *S. americanus*. It is worthy of remark, in this connection, that I have found the cheek pouches of *S. canadensis* much the more frequently and conspicuously distended with food.

Sitomys americanus canadensis is exclusively a Canadian form, replacing *S. americanus* in the spruce forests of New Brunswick (Restigouche county, E. A. Bangs; Northumberland county, G. S. Miller), and extending south among the hills and mountains at least to central New York and western Massachusetts. *Sitomys americanus* is found as far north as Digby, Nova Scotia, and Lake Simcoe, Ontario. Thus the ranges of the two forms overlap geographically about two hundred miles. Nevertheless, the conditions under which the animals live are essentially different, *S. canadensis* confining itself to dense, preferably damp woods—such as *Troglodytes hiemalis* and *Certhia familiaris americana* choose to breed in—while *S. americanus* is a mouse of the open fields, clearings, and neighborhood of houses. Only in the central and southern part of its range, where the character of the country is very different from that inhabited by *S. canadensis*, does the smaller animal take to the woods with anything like regularity. I have no doubt that the northward range of *S. americanus* has been considerably extended by a gradual movement, following the clearing away of the forests, thus bringing the two races into their now curiously close juxtaposition.

For the present at least I have thought it best to treat these two animals as subspecies. It must be confessed, however, that the number of intermediates is surprisingly small, less than a dozen in the total number of specimens examined, and that these occur in no particular geographical region. The case is susceptible of no definite proof until more facts are forthcoming; meanwhile it lies with each observer to treat these closely allied forms as his individual preference may dictate.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
2011	1763	Sutton, West Ontario, Canada.	Nov. 25, '92	♀	167	74	3.8	21.6	17	44 3
2012	1764	“ “	Dec. 1, '92	♀	160	70	3.6	20	15.4	43.7
2231	......	Digby, N. S......	Oct. 9, '92	♂	166.5	80.5	3.4	20.5	17.5	47.7*
2232	......	“ “	“ 9, '92	♂	164	78	2.8	20.5	16	47.5
2233	......	“ “	“ 11, '92	♀	172	83	3	19.5	17	48.9
2234	......	“ “	“ 13, '92	♀	167.5	82	4	19.5	15.5	48.3
2235	......	“ “	“ 13, '92	♀	166.5	79	3.8	20	15	47.4
2236	......	“ “	“ 16, '92	♂	163	79	3	19	17.5	48.4
2237	......	“ “	“ 16, '92	♀	156.5	72.5	2.4	20	15.5	46.3
2238	......	“ “	“ 17, '92	♀	154.5	70.5	3.4	20.5	16	44.9
2239	......	“ “	“ 17, '92	♂	156.5	74.5	3	20.5	16	41.2
2240	......	“ “	“ 21, '92	♀	157	71	3	19	17	45.2
2241	......	“ “	“ 23, '92	♀	166.5	80	3.4	20.5	14.5	48.4
2242	......	“ “	“ 23, '92	♂	159	73	2.4	19.5	15.5	45.9
1024	873	Elizabethtown, N. Y.	Dec. 20, '91	♀	169	74	3.6	20.4	17	43.1
1025	874	“ “	“ 21, '91	♂	165	74	3.4	22	16.8	44.8
1042	890	“ “	“ 27, '91	♂	170	76	4	20	16.4	44.7
1049	897	“ “	“ 28, '91	♀	180	79	3.2	19.5	16.2	43.9
1054	902	“ “	“ 29, '91	♂	167	68	3.2	20.4	16.2	40.7
1055	903	“ “	“ 30, '91	♂	162	68	3.6	20.4	16.2	41.9
1059	907	“ “	“ 31, '91	♂	168	74.8	3.6	21	14.8	44
1060	908	“ “	“ 31, '91	♀	160	71	3.4	20.5	15.4	44.3
1063	911	“ “	Jan. 1, '92	♂	168	71	4.4	20	14	42.3
1065	913	“ “	“ 1, '92	♂	158	66.5	3	20.2	14 8	42.1
1066	914	“ “	“ 1, '92	♀	158	70	3	20	15.6	44.3
1140	967	“ “	“ 3, '92	♂	181	83	4.2	21	17	45.8
1141	968	“ “	“ 3, '92	♂	169	71	3.4	21	17	44.1
1282	1109	“ “	Feb. 27, '92	♂	166	74	3.6	21	16	44.6
1292	1112	“ “	Mar. 10, '92	♀	154	69	2.8	20.5	15.5	44.8
1352	1169	“ “	Apr. 3, '92	♀	163	68	3.2	20	16	41.7
1353	1170	“ “	“ 4, '92	♀	157	67	3	20	14.8	42.6
1355	1172	“ “	“ 11, '92	♀	172	71	3.8	19	15.2	41.3
1356	1173	“ “	“ 4, '92	♂	176	80	4	20	14.5	45.4
1357	1174	“ “	“ 5, '92	♂	175	76	2.8	19.4	16.8	43.4
258	......	Peterboro, N. Y.	July 15, '90	♀	175	76	3.6	19.3	14	43.5
1595	1392	“ “	“ 20, '92	♀	192	86	4.4	21	16	45
1640	1437	“ “	Aug. 3, '92	♀	172	76	....	20	16.4	44
1648	1444	“ “	“ 17, '92	♀	172	76	4	19	17	44
1649	1445	“ “	“ 17, '92	♂	185	80	4	20.8	18	43
1652	1448	“ “	“ 19, '92	♀	177	75	2.4	20.2	16.2	42
1653	1449	“ “	“ 19, '92	♂	164	72	3.4	20.6	16	44
1654	1450	“ “	“ 20, '92	♀	170	76	1.8	20.4	16	45
1683	1478	“ “	Sept. 9, '92	♀	190	85	4.4	22	18	45
1708	1499	“ “	“ 17, '92	♀	155	69	2	19	17	45
1709	1500	“ “	“ 17, '92	♀	156	71	2	20	16	45
1710	1501	“ “	“ 17, '92	♂	167	76	3.4	20	17	46
1716	1507	“ “	“ 25, '92	♂	152	66	3.4	19.8	14.4	43.4

* Collected and measured by Outram Bangs.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (*Kerr*).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1997	1760	Peterboro, N. Y.	Nov. 9, '92	♂	168	75	3	22	16	44.6
283	......	Geneva, N. Y....	Dec. 25, '90	♀	165	71	3.4	20.4	17	43
284	......	“ “	“ 27, '90	♀	165	72.5	3.8	19	16	43.3
1153	980	West Dedham, Mass.	Jan. 30, '92	♂	184	82	3	20.4	14.5	43.5
1154	981	“ “	“ 30, '92	♂	178	78	3.2	20.8	15	43.8
1155	982	“ “	“ 30, '92	♂	163	69.6	3.2	20.5	16	42.7
1156	983	“ “	“ 30, '92	♂	169	72	3.2	21	15.8	42.6
1157	984	“ “	“ 30, '92	♂	183	82	4	20	16	44.8
1158	985	“ “	“ 30, '92	♂	165	70	3	21	15.8	42.4
1159	986	“ “	“ 30, '92	♂	179	78	3.4	21	14.8	43.6
1160	987	“ “	“ 30, '92	♀	172	79	4	21	15.2	45.9
1161	988	“ “	“ 30, '92	♀	165	72.5	4	20.5	15	43.9
1162	989	“ “	“ 30, '92	♀	179	78.5	3.4	23	16.5	43.9
1163	990	“ “	“ 30, '92	♀	173	76	5	20.2	17	43.9
1164	991	“ “	“ 31, '92	♂	162	69	3.4	20.5	14.8	42.5
1165	992	“ “	“ 31, '92	♂	167	76	3.6	20	15.4	45.5
1166	993	“ “	“ 31, '92	♀	163.5	72	3.2	19	13.5	44.3
1167	994	“ “	“ 31, '92	♀	163	72	4	21	17	44.1
1168	995	“ “	“ 31, '92	♀	163	70	3.8	20	14.8	42.9
1402	1218	“ “	May 8, '92	♀	182	81	2.4	20	16	44.5
1173	1000	“ “	“ 1, '92	♂	171	74	3.4	20.5	15	43.2
1174	1001	“ “	“ 1, '92	♀	159	66	3.2	21.4	16.4	41.5
1175	1002	“ “	“ 1. '92	♀	174	77	5	20.2	15	44.2
1402	1218	“ “	“ 8, '92	♀	182	81	2.4	20	16	44.5
448	372	Seekonk, Mass...	April 6, '91	♀	195	88.5	3.4	20.8	17.2	45.4
919	805	“ “ ...	Nov. 28, '91	♂	179	79	4.6	21	14.8	44.1
920	806	“ “ ...	“ 28, '91	♂	152	66	....	20.4	14.8	43.4
922	808	“ “ ...	“ 29. '91	♂	167	87	3.4	20.2	15	46.7
923	809	“ “ ...	“ 29, '91	♂	162	67.4	3.8	20.4	15	41.6
924	810	“ “ ...	“ 29, '91	♂	184	85.5	2.8	20.8	15.8	46.5
926	812	“ “ ...	“ 27, '91	♀	190	88.5	3 2	20.8	15.6	46.6
927	813	“ “ ...	“ 27, '91	♀	171	76.6	3	20.5	15.6	44.8
928	814	“ “ ...	“ 29, '91	♀	188	84	4.2	20.4	17	44.7
929	815	“ “ ...	“ 29, '91	♀	181	76	4	20.5	15	42
931	817	“ “ ...	“ 29, '91	♀	196	94	3	20.6	15.4	47.9
932	818	“ “ ...	“ 29, '91	♀	163	75.6	3.6	20.8	16.4	46.4
933	819	“ “ ...	“ 29, '91	♀	180	79	3.6	19.8	14.4	43.9
936	822	“ “ ...	“ 30, '91	♀	178	75.5	3.2	19.8	15.8	42.4
2014	......	“ “ ...	Dec. 12, '92	♀	193	86	4.2	20	16	44.6
2289	......	Concord, Mass ...	Nov. 5, '92	♂	159	69	4	20	15	43.4
2290	......	“ “ ...	“ 5, '92	♂	158	69	3	20.4	15	43.6
1399	1215	Weston, Mass....	May 2, '92	♂	170	72	3	20.8	17	42.3
1400	1216	“ “	“ 2, '92	♂	180	79	2.8	20.8	16.8	43.9
1401	1217	“ “	“ 2, '92	♀	166	68	2.6	20	17	41
436	357	Ipswich, Mass ...	Mar. 21, '91	♂	176	82.5	3	20.5	16	46.9
437	358	“ “ ...	“ 21, '91	♂	162	75	2.6	20	15.8	46.3
439	360	North Truro, Mass.	April 1, '91	♀	188	83.5	3	19.5	16.2	44.4
440	361	“ “	“ 1, '91	♀	156	66	3	19.5	17	42.3

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (Kerr).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
441	362	North Truro, Mass.	April 1, ’91	♀	152	65	4	20	16	42.1
442	363	“ “	“ 1, ’91	♂	148	67	3.2	20	16.4	45.3
443	364	“ “	“ 1, ’91	♂	153	65.5	3	19.5	16	42.1
444	365	“ “	“ 1, ’91	♂	156	68	3.6	20	14.5	43.6
451	366	“ “	“ 1, ’91	♂	164	69	....	20	16	42.1
749	642	“ “	Sept. 22, ’91	♂	169	78	2.6	21	16.8	46.1
1422	1234	“ “	May 22, ’92	♂	182	85	....	21	17	46.7
1525	1331	“ “	June 24, ’92	♀	183	82	3	20.2	16.2	44.8
1527	1333	“ “	“ 24, ’92	♂	167	74	....	20	17	44.3
1529	1335	“ “	“ 25, ’92	♂	188	83	2.4	20	16	44.1
1530	1336	“ “	“ 28, ’92	♂	175	80	2.4	21	15.4	46
1531	1337	“ “	“ 28, ’92	♂	180	79	2.4	20	16.8	44
1	......	Liberty Hill, Conn.	Nov. 21, ’92	♂	178.5	78	3.8	20	17.5	43.2*
3	......	“ “	“ 22, ’92	♂	145	57.5	3	20	14	40
4	......	“ “	“ 22, ’92	♂	173.5	74.5	4	20.5	15	42.9
5	......	“ “	“ 22, ’92	♂	164.5	70	3.8	20.5	15	41.9
7	......	“ “	“ 23, ’92	♂	158	71	3	20.5	14.5	44.2
9	......	“ “	“ 26, ’92	♀	171	77	5.2	21.5	19	45
10	......	“ “	“ 26, ’92	♀	167.5	78.5	3.8	20	18	46.9
13	......	“ “	“ 26, ’92	♀	151	69	4	19	18	45.6
14	......	“ “	“ 26, ’92	♂	146	66	3.2	20	18	45.2
15	......	“ “	“ 26, ’92	♂	142	61	3.6	18	15	43
16	......	“ “	“ 26, ’92	♂	166.5	74.5	3.4	19	17	44.7
17	......	“ “	“ 26, ’92	♀	151	65	4.2	20	17	43
18	......	“ “	“ 26, ’92	♀	165	75	3.8	19	15	45.4
19	......	“ “	“ 26, ’92	♂	158	69	3.4	18	15	43.6
20	......	“ “	“ 26, ’92	♀	164	74	3.4	19.5	17.5	45.5
1	......	“ “	Dec. 14, ’92	♀	175	80	3.4	20.5	17	45.7
1	......	“ “	“ 15, ’92	♀	173	73	3.8	21	15.5	42.2
13	......	Haddonfield, N. J.	“ 24, ’91	♂	169	73	5	21.3	15.2	41.6†
15	......	“ “	“ 24, ’91	♀	165	74.7	3	19.3	16.3	45.3
18	......	“ “	“ 24, ’91	♂	141	62	3	19.3	15.7	44
30	......	“ “	“ 26, ’91	♂	152	66.5	4	20.3	16.3	43.7
32	......	“ “	“ 26, ’91	♂	143	63.5	3.6	19	14.7	43.7
38	......	“ “	“ 27, ’91	♂	155.4	71.6	3.2	20.3	17.5	46.1
51	......	“ “	“ 28, ’91	♂	156	66	3.6	19.3	15.7	42.3
57	......	“ “	Jan. 11, ’92	♂	153	64	4	21.6	17	41.8
88	......	“ “	“ 22, ’92	♀	174	82	4.2	20.3	15.7	47.1
90	......	“ “	“ 23, ’92	♂	159	69.8	4.2	19.6	16	43.9
118	......	“ “	Feb. 2, ’92	♂	171	74.2	3.8	23	17	43.4
125	......	“ “	“ 3, ’92	♀	152	67.3	4	21.3	16.5	44.3
146	......	“ “	“ 13, ’92	♀	165	73	4	20	16	44.2
152	......	Thorndale, Pa....	“ 18, ’92	♂	157	67	3.6	21	10	42.6
134	......	Barren Ridge, Pa.	“ 7, ’92	♂	161	67	3.4	21	15.2	40.3
135	......	“ “	“ 7, ’92	♂	149	58	4	20.3	15.7	39.6
58	......	Marple, Pa.......	Jan. 13, ’92	♂	152	63	3.8	21	16	41.4
61	......	“ “	“ 14, ’92	♂	157	67	4	20.3	15.2	42.6
71	......	“ “	“ 15, ’92	♂	140	57	2.4	20.3	16.8	40.7

* Collection of Outram Bangs; measured by collector.

† Collection of S. N. Rhoads; measured by collector.

Measurements of One Hundred and Fifty Specimens of Sitomys americanus (*Kerr*).

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
74	......	Marple, Pa.......	Jan. 16, '92	♂	154	63	3	20.3	16	41
75	......	" "	" 16, '92	♂	156	69	3.8	22	15.2	44.3
2132	1862	Washington, D. C.	Feb. 12, '93	♀	194	91	2	21	17	46.9
2133	1863	" "	" 12, '93	♀	185	85	2.8	20	15	45.9
2134	1864	" "	" 12, '93	♂	165	76	3.6	21	16	46.6
2135	1865	" "	" 12, '93	♂	177	84	3.4	20	16	47.4
2136	1866	" "	" 12, '93	♂	165	72	3	21	16	43.6

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1436	......	Northumberland Co , N. B.	June 6, '92	♂	170	83	....	19.8	16.8	48.8
1437	......	" "	" 9, '92	♀	150	73	....	19.8	16	48.7
1419	1231	Oak Bay, N. B....	Apr. 11, '92	♀	155	75	5	19.8	15.6	48.4*
1848	1626	" "	May 18, '92	♀	185	90	6	20	16	48.6
1032	881	Elizabethtown, N. Y.	Dec. 23, '91	♂	181	91	7.4	20.2	17.8	50.3
1033	882	" "	" 23, '91	♀	197	100.5	8	20	17.4	51
1034	883	" "	" 23, '91	♂	170	84	6.8	19.4	16	49.4
1043	891	" "	" 27, '91	♀	165	82	5.6	18	17	49.7
1044	892	" "	" 27, '91	♀	165	86	6.8	20	17	52.1
1048	896	" "	" 28, '91	♂	178	89	7.4	20	16.8	50
1056	904	" "	" 30, '91	♂	196	100	7.8	20	17.2	51
1061	909	" "	" 31, '91	♀	184	91	6.8	20	16.5	49.5
1062	910	" "	" 31, '91	♂	166	81	6.6	19.8	17.6	48.8
1067	915	" "	Jan. 1, '93	♂	173	85	5.4	20	18.2	49.1
1142	969	" "	" 3, '93	♀	171	81	5.4	20.5	18	47.4
1143	970	" "	" 3, '93	♀	176	84	6	20	16.5	47.7
1181	1008	" "	Feb. 4, '93	♂	189	95	6.6	21	16	50.3
1208	1035	" "	" 17, '93	♂	170	83	4.4	21.5	15	49
1209	1036	" "	" 17, '93	♀	162	81	4.4	21.5	14	50
1223	1050	" "	" 19, '93	♂	185	92	4.6	21.5	15	49.7
1224	1051	" "	" 19, '93	♂	181	90	5.8	21.2	16	49.7
1284	1104	" "	" 21, '93	♀	168	85	4.6	22	17	50.6
1286	1106	" "	" 25, '93	♂	173	89.5	6.2	20	17	51.7
1287	1107	" "	" 25, '93	♂	170	85	6.4	19.5	16	50
1288	1108	" "	" 25, '93	♂	169	81	5	22	18	47.9

* Collected and measured by H H. McAdam.

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1365	1181	Elizabethtown, N. Y.	Mar. 28, '93	♀	160	80	4.8	19	18.5	50
1368	1184	“ “	April 6, '93	♀	173	83	7.8	20.4	17	47.9
1369	1185	“ “	“ 6, '93	♀	186	88.5	6.4	20.4	17	47.6
1370	1186	“ “	“ 9, '93	♀	172	85	6	21	17.2	49.4
1371	1187	“ “	“ 4, '93	♂	179	86	7.4	20	17	48
1372	1188	“ “	“ 4, '93	♂	185	93	7.2	19.4	18	50.2
1373	1189	“ “	“ 6, '93	♂	187	90	8.2	21	18.2	48.1
1374	1190	“ “	“ 10, '93	♂	177	85	7.2	21	16.2	48
1375	1191	“ “	“ 10, '93	♂	181	88.5	7	21.2	19	48.9
1285	1105	“ “	Feb. 25, '93	♀	172	85	3.2	20	17	49.8
1361	1178	“ “	April 4, '93	♀	182	90	6.6	20.4	18.2	49.5
1362	1179	“ “	“ 9, '93	♀	193	92.5	7.8	20	16.8	47.9
1573	1370	Peterboro, N. Y.	July 17, '93	♀	172	85	6.8	20	17.6	49
1579	1376	“ “	“ 18, '93	♀	172	85	5.7	20	18	49
1580	1377	“ “	“ 18, '93	♀	200	100	6.4	21	18.8	50
1582	1379	“ “	“ 18, '93	♀	190	97	7.8	21.2	18	51
1583	1380	“ “	“ 18, '93	♀	182	95	7.4	21.8	17.6	52
1584	1381	“ “	“ 18, '93	♀	172	84	7	20.6	17	49
1585	1382	“ “	“ 18, '93	♂	196	102	6	21.4	18	52
1586	1383	“ “	“ 18, '93	♂	195	101	9	21	19	52
1587	1384	“ “	“ 18, '93	♂	195	98	7	21	17.2	50
1588	1385	“ “	“ 19, '93	♀	175	91	6	21	19	52
1589	1386	“ “	“ 19, '93	♂	196	98	7	21	19.2	50
1590	1387	“ “	“ 19, '93	♂	176	85	5.2	20.8	18	48.3
1591	1388	“ “	“ 19, '93	♂	165	84	5.6	20	18	50.9
1593	1390	“ “	“ 19, '93	♂	187	92	7.8	21.6	18	49.2
1597	1394	“ “	“ 20, '93	♀	171	87	6.6	20	18	50.9
1598	1395	“ “	“ 20, '93	♀	172	87	5.6	19.8	19	50.6
1599	1396	“ “	“ 20, '93	♂	206	108	7	21.8	18.8	52.4
1600	1397	“ “	“ 20, '93	♂	188	99	6.6	21.8	16.8	52.7
1601	1398	“ “	“ 20, '93	♂	175	86.5	6.6	20	18.2	49.4
1602	1399	“ “	“ 20, '93	♂	185	96	6.8	21.8	19	51.9
1603	1400	“ “	“ 20, '93	♂	180	89	5.4	21.8	19	49.4
1606	1403	“ “	“ 21, '93	♀	175	87	7	21	19	49.7
1607	1404	“ “	“ 21, '93	♀	175	90	6	21	16.6	51.4
1608	1405	“ “	“ 21, '93	♂	188	94	9	21	18	50*
1610	1407	“ “	“ 21, '93	♂	179	93	5.4	20	18	51.9
1611	1408	“ “	“ 21, '93	♂	180	91	6	21.2	19.6	50.4
1612	1409	“ “	“ 24, '93	♀	200	100	6.6	21.4	19	50*
1613	1410	“ “	“ 24, '93	♀	195	100	5.4	21	19	51.3
1615	1412	“ “	“ 24, '93	♂	177	90	6.8	21	18	50.8
1619	1416	“ “	“ 25, '93	♂	180	93	5.2	21	18	51.7
1620	1417	“ “	“ 25, '93	♂	175	87	6.6	21	17.4	49.7
1621	1418	“ “	“ 25, '93	♂	178	90	5.4	21.4	18	50.6
1630	1427	“ “	“ 30, '93	♀	217	114	10.8	22	18.8	52.5
1638	1435	“ “	Aug. 1, '93	♀	201	105	11	21	17.8	52.2*
1639	1436	“ “	“ 1, '93	♂	189	100	5	21	17	52.9
1642	1438	“ “	“ 5, '93	♂	170	83	7.8	20	17	48.8

*Type.

Measurements of One Hundred Specimens of Sitomys americanus canadensis Miller.

Number.		Locality.	Date.	Sex.	Total length.	Tail vertebræ.	Pencil.	Hind foot.	Ear from notch.	Ratio of tail vertebræ to total length.
Skin.	Skull.									
1643	1439	Peterboro, N. Y.	Aug. 5, '92	♂	176	85	8.2	20.2	17	48.3
1644	1440	" "	" 6, '92	♂	171	86	9.2	20.4	18	50.3
1645	1441	" "	" 7, '93	♀	180	96	6.8	21	18	53.3
1651	1447	" "	" 18, '93	♀	202	104	8	20.6	20	51.5
1655	1451	" "	" 22, '93	♀	195	103	8	19	19	52.8
1661	......	" "	" 23, '93	♂	195	100	8	20	19.8	51.3
1662	1458	" "	" 25, '93	♂	188	101	5.8	21	20	53.2
1670	1465	" "	" 26, '93	♀	214	116	6.2	21.4	18.4	54.2
1671	1466	" "	" 26, '93	♂	202	105	7.4	21	18	52
1672	1467	" "	" 26, '93	♂	189	101	6.9	20	19	53.6
1680	1475	" "	Sept. 7, '93	♀	192	98	5	20.2	18.8	51
1681	1476	" "	" 7, '93	♂	187	92	6.1	22	18	49.2
1685	1480	" "	" 10, '93	♂	192	98	10	21	19.4	51
1686	1481	" "	" 10, '93	♂	183	94	9.4	22	19	51.4
1687	1482	" "	" 10, '93	♂	187	98	6.4	22.8	20	52.4
1688	1483	" "	" 10, '93	♂	183	95	7	21.8	18.4	51.9
1692	1487	" "	" 11, '93	♀	182	95	8.6	21.8	19.8	52.3
1693	1488	" "	" 11, '93	♀	172	87	8	20.2	18	50.6
1697	1491	" "	" 15, '93	♀	182	94	6.8	21	19	51.6
2003	......	" "	Oct. 14, '93	♂	182	93.6	7.8	21	19	51.9
2004	......	" "	" 19, '93	♀	173	90	7.4	20.4	18	52
2009	......	" "	Nov. 3, '93	♂	180	94	8.4	20	17	52.2
2010	......	" "	" 8, '93	♂	200	102	8.4	20	19	51
2292	......	Mount Graylock, Mass.	May 8, '93	♀	198	96	7.4	22	19	48.5
2293	......	" "	" 8, '93	♀	188	94	7	21.2	18	50
2294	......	" "	" 8, '93	♀	200	103	9	22.2	17	51.5
2295	......	" "	" 8, '93	♂	202	98	8	22.2	19	48.5

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DEVELOPMENT OF THE BRACHIAL SUPPORTS IN DIELASMA AND ZYGOSPIRA.

BY CHARLES E. BEECHER AND CHARLES SCHUCHERT.

It has been shown by several authors* that the brachial supports in the Terebratellidæ pass through a series of distinct metamorphoses during the life of the animal. In the higher genera, these stages may be correlated with the adult structures of lower forms, thus furnishing satisfactory data for a systematic arrangement of the genera and for their phylogenetic relations.

This kind of research naturally requires ontogenetic series of considerable completeness, and it is often difficult or impossible to obtain such material representing fossil forms. Moreover, the fossils must be exceptionally well preserved to afford a means of working out the development of a structure so delicate as the calcareous lamellæ supporting the brachia, especially in young specimens from one to five millimeters in length.

It first seemed desirable to determine the development in some genus of the Terebratulidæ from the Paleozoic, in order to ascertain whether the brachial supports as in Neozoic and recent forms passed through a series of transformations, and to determine the most primitive form of the loop in the Ancylobrachia. For this purpose, a species of *Dielasma* (*D. turgida*) obtained from Mr. Moritz Fischer was used. The specimens are from the St. Louis group of the Lower Carboniferous in Kentucky. The shells are partially silicified, generally filled with transparent calcite, and afford very satisfactory preparations of the arm supports. It was found that the loop of *Dielasma* underwent transformations during growth, and that the earliest stage observed is like *Centronella.* This establishes the *centronelliform* loop as the simplest type of loop in the Ancylobrachia. Besides *Centronella*, other adult representatives of the same structure are *Rensselæria* and *Newberria.* They are all late Silurian, Devonian, and Carboniferous genera, but the *centronelliform* structure continues later, and is represented in the Trias by the genera *Juvavella* Bittner and *Nucleatula* (Zugmayer) Bittner.

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* Davidson, Friele, Deslongchamps, Fischer and Œhlert, and Beecher.

It was at once suggested that interesting results would be obtained in studying the development of a spire-bearing brachiopod, and, as the earliest species more clearly show their phylogeny in their ontogeny, the ancient genus *Zygospira* was selected. Very complete material was accessible, collected by the writers from the Trenton of Minnesota and Kentucky, so that series of specimens were assembled representing all stages of growth from specimens .8 mm. in length to mature size. They were prepared to show their brachial supports, and it is clearly demonstrated that the primitive arm support in *Zygospira* is a terebratuloid loop having a *Centronella*-like form, which undergoes several modifications before the growth of the spiral lamellæ, and thus in so far resembling the development of *Dielasma.*

These results threw doubt on a number of Lower and Upper Silurian species described as having recurved loops and previously referred to the higher terebratuloid genera *Macandrevia* or *Waldheimia.* The shells are impunctate, while *Rensselæria* and *Centronella* are distinctly punctate, like all other well-known terebratulæ. Upon investigation, it has been ascertained by Hall and Clarke and the authors that the species which have been referred to *Hallina* and *Macandrevia* from the Silurian are spire-bearing forms, and therefore do not belong to the Ancylobrachia.

Fischer and Œhlert have called attention to a number of recent species which have been erroneously based upon the immature stages of higher species, and in the Terebratellidæ it is evident that great uncertainty must exist in the identification ot specimens not fully adult. Now, finding that Paleozoic genera of both loop and spire-bearing stocks (Ancylobrachia and Helicopegmata) in the adolescent period likewise pass through metamorphoses representing the structures of other genera and even other suborders, it is manifest that species cannot be referred to their proper genera nor genera correctly defined unless the individuals studied are adult and their characters constant for a definite period of time.

Development of the Loop in Dielasma turgida.

The earliest stage thus far observed was found in a specimen a little over four millimeters in length (plate x, fig. 1). The loop at this time is composed of two broad descending lamellæ, which begin at the ends of the crura and extend forward, curving ventrally until they unite in the median line, forming an angular ridge, acuminate in front. As previously mentioned, this structure is very similar to that of *Centronella*, and this stage is therefore called the *centronelliform* stage.

The first change in the form of the loop is brought about by a resorption of the pointed anterior portion, so that the outline is reëntrant in front (fig. 2). Further resorption in the same manner results in the production of two posteriorly directed branches, as shown in fig. 3. This form may be considered as an early immature *Dielasma* loop, as subsequent growth does not materially modify its general characters.

The adult loop, represented in figs. 4–6, differs from the early *Dielasma* stage chiefly in the divergence of the descending branches.

In the *centronelliform* stage the lamellæ converge, and the loop extends half the length of the shell. Both of these relations gradually alter until, in the early *Dielasma* stage, the descending branches are nearly parallel, the loop extends less than half the length, and, finally, when mature, the descending branches diverge and the loop is two-fifths the length of the dorsal valve.

The natural inferences to be drawn from the development of the loop in *Dielasma* are, that *Centronella* represents a larval or immature condition of the higher genera, and that the *centronelloid* loop is the primitive type in the Terebratulidæ. Therefore, as *Centronella* and the closely related genus *Rensselæria* are the only early punctate terebratuloids known, and as they have the primitive type of loop, there arises the question of the validity of the Upper and Lower Silurian species with recurved loops, referred to *Waldheimia* and *Hallina.*

Hall and Clarke (Pal. N. Y., vol. VIII, part ii, pp. 147–153, not yet published) describe and figure the brachial supports in *Hallina*, showing that both *H. nicoletti*, Winchell and Schuchert and *H. saffordi*, W. and S. are provided with short spires of about one volution, connected by a transverse band, as in *Zygospira.* In removing the ventral valve and exposing the loop from that side, as is often done, the short spiral lamellæ have been overlooked. Similar observations have been made by the present writers, so that the systematic position of these forms is now established.

Specimens of *Waldheimia bicarinata* Angelin, from the Upper Silurian of Gotland, were also examined. They were found to possess well-defined spiral cones, and in other respects agreed with the diagnosis of *Dayia.* These facts indicate that the specimens described by Davidson as *Waldheimia mawii* (Fossil Brachiopoda, Supp. vol. IV, part v, pl. iv, figs. 1–3) are the young of *Dayia navicula* Sowerby, sp. (*ibid.*, pl. v, figs. 1–4).

Development of the brachial Supports in Zygospira recurvirostra.

The smallest specimen in which the internal structure was observed measures about 1.33 mm. in length (plate x, figs. 7, 8). The brachial supports consist of two straight, ventrally concave, primary lamellæ, rapidly increasing in width from the thin crural plates to near the center of the valve, where they unite, forming a plate with a central angular ridge. The anterior end of the plate is pointed as in *Centronella.*

In a specimen about 2 mm. in length (figs. 9, 10), the primary lamellæ are practically of the same form as in the preceding, but much of the original central portion of the loop has been resorbed, so that the lamellæ are connected by a short but comparatively wide, ventrally arched, transverse band. The lamellæ, or descending branches, are also more spreading anteriorly, and there is a slight deflection at the crural points, which becomes more and more pronounced as growth progresses.

In the next stage (fig. 11), which has a length of 2.33 mm., the descending branches are more diverging, and the transverse band is longer and more broadly excavated in front.

The succeeding stages here described are based upon material derived from near the top of the Trenton, where the specimens of this species are usually larger and more transverse than those from near the base of the Trenton, which is the horizon of the specimens illustrated in figs. 7–11. Therefore, when the loop in fig. 9 is compared with that of fig. 12, it is seen that the latter is much the wider, from the greater size and breath of the shell, which has at this stage a length of 3.33 mm., while the former is but 2 mm. long. The loop in fig. 12 is somewhat more advanced than in fig. 9, the transverse band being narrower and slightly elevated posteriorly, some resorption having taken place along the inner edges of the primary lamellæ. Further resorption in same direction produces the brachial support illustrated in fig. 14. This form of loop in *Z. nicoletti*, *Z. saffordi*, and *Z. recurvirostra* from the lowest Trenton is retained to maturity. However, in specimens of *Z. recurvirostra* from the upper Trenton the posteriorly curved, transverse band is not a mature feature, since it becomes changed into the form represented in fig. 15. In previous stages the transverse band is ventrally arched, but it now bends dorsally, and remains so during subsequent growth until near maturity, when the sinus of the dorsal valve causes it to assume a sigmoid curve.

The spirals next begin to develop (figs. 16 and 17) as two slender converging lamellæ, curving toward the ventral valve and originating from the outer pointed ends of the loop. These lamellæ then incurve dorsally and laterally to a point just posterior to the transverse band, forming the first volution of a spiral (fig. 18). In this manner further growth and elongation of the lamellæ continue until maturity is attained, when there are about three volutions in each spiral cone (fig. 20). The calcareous brachial supports occupy about the same relative space in the shell cavity in all stages of growth.

Observations and Correlations.

Zygospira is the earliest spire-bearing genus known, as it is found in the Birdseye limestone of the Trenton period. It is of considerable interest, therefore, to study the development of the spirals. From the ontogeny, it is shown that the brachial supports in *Zygospira* begin as a loop greatly resembling that of Devonian *Centronella*. Moreover, the loop passes through a series of metamorphoses before the spirals make their appearance.

The most ancient species are *Z. nicoletti* and *Z. saffordi*, small semiplicate forms, in which the spirals are very rudimentary, consisting of about one volution. In the same geological horizon occurs *Z. recurvirostra*, having from two to two and one-half turns of the lamellæ in each spiral. The same species from the upper Trenton has three volutions, while in *Z. modesta* of the middle Lorraine there are from four to five whorls (fig. 25). In *Z. headi* (fig. 24), a large globose finely striated species of the upper Lorraine, there are six whorls to a cone. The geological history, therefore, shows a gradual increase of from one to six turns of the lamellæ in each spiral.

The transverse band connecting the primary lamellæ also undergoes a series of changes. It has been shown that the centronelloid loop (fig. 7) passes into one having the lamellæ joined by a posteriorly directed, transverse band (fig. 14). This form of loop is retained as a mature feature in the brachia of *Z. nicoletti*, *Z. saffordi*, and in the lower Trenton varieties of *Z. recurvirostra*. Passing to the specimens of the latter species, which are geologically later, the band no longer joins the lamellæ as far anteriorly as in the older variety (fig. 20). The point of connection in *Z. modesta* is variable (figs. 25 and 26), but is usually more posterior than in *Z. recurvirostra*, while in *Z. headi* it is manifestly more posterior than in any of the older species of *Zygospira*. The transverse band is now no longer arched backward, but is just the reverse (fig. 24), while its position is progressively more and more posterior, and the loop is gradually shortened before the spirals make their appearance. The gradual increase in the number of the whorls in each spiral and the recession of the transverse band have gone on together.*

The family Atrypidæ includes the genera *Zygospira*, *Glassia*, *Cœlospira*, *Anoplotheca*, *Atrypa*, and *Dayia*. It is easily distinguished from all other families comprised in the suborder Helicopegmata, since the spirals are between the first descending branches of the lamellæ, while in the Spiriferidæ, Nucleospiridæ, and Athyridæ the primary lamellæ are between the spirals.

The gradual increase in the number of whorls in the spirals and the pushing backward of the transverse band in the Atrypidæ is carried farthest in the species of *Atrypa*. In *Cœlospira*

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* The extreme anterior position of the transverse band in *Z. recurvirostra* is therefore of no more than specific value, and on this account *Anazyga* Davidson cannot well be separated from *Zygospira*.

barrandei and *C. marginalis* the brachial supports, as worked out by Davidson and Glass, consist of about five volutions, and are similar to those of *Zygospira*, except that the transverse band is more posterior, since it originates near the ends of the crura. This mature condition of *Cœlospira* is seen to be a young condition of *Atrypa* (Davidson), but, as the spirals are more loosely coiled and the transverse band always continuous, this genus should be regarded as valid in the evolution from *Zygospira* to *Atrypa*. In mature *Atrypa reticularis* from the Upper Silurian, there may be as many as sixteen volutions in each spiral cone (Davidson), but more often the number is smaller. The transverse band in this species during its young stages is continuous, but in the adult condition it seems to be usually disunited in the middle. This feature becomes a distinct adult character in the Devonian specimens, which also have a greater number of whorls in the spirals, as shown in a Chemung specimen of this species in Yale University Museum, having twenty-four turns of the lamellæ in each spiral.

The ontogeny and phylogeny of the species of *Zygospira* indicate strongly that the *Atrypidæ* had its origin in a form with a centronelloid loop. A further natural conclusion from the same evidence is that the Ancylobrachia are older and more primitive than the Helicopegmata.

EXPLANATION OF PLATE X.

Dielasma turgida.

Figure 1.—The *centronelliform* stage of the loop; ventral view. × 6.
2.—A later stage, showing the resorption of the anterior portion of the loop. × 6.
3.—Early *Dielasma* stage, produced by further resorption of the centronelloid loop. × 6.
4.—Loop and crural plates of mature specimen. × 6.
5.—Profile of the connecting band. × 6.
6.—Side view of the loop, crura, and septum. × 6. St. Louis group, *Kentucky*.

Zygospira recurvirostra.

Figure 7.—*Centronelliform* stage of the loop. × 12.
8.—Profile of same. × 12.
9.—A later stage; showing partial resorption of loop in front and greater divergence of descending branches. × 12.
10.—The same; profile. × 12.

Figure 11.—A little more advanced stage, showing increased length of connecting band. × 12. Specimens figures 7–11 are from the Trenton shales, *St. Paul, Minnesota.*

12.—A looped stage, with broad, curved, descending branches and more slender transverse band. × 6.

13.—The same; profile. × 6.

14.—A later stage, showing more slender loop. × 6.

15.—A specimen showing curved, diverging, descending branches, long transverse band, and two projections of the lamellæ, which are the beginning of the spiral cones. × 6.

16.—A subsequent stage in which the lamellæ are more extended and ventrally and inwardly curved. × 6.

17.—The same; profile. × 6.

18.—A young individual in which there are about one and one-half turns to each spiral. × 6.

19.—The same; profile. × 6.

20.—The brachial supports in a mature specimen. × 6. The specimens figures 12–20 are from the top of the Trenton, *Frankfort, Kentucky.*

21.—The spirals and loop in a Canadian specimen of (*Anazyga* =) *Zygospira recurvirostra.* (After Davidson.) × 3.

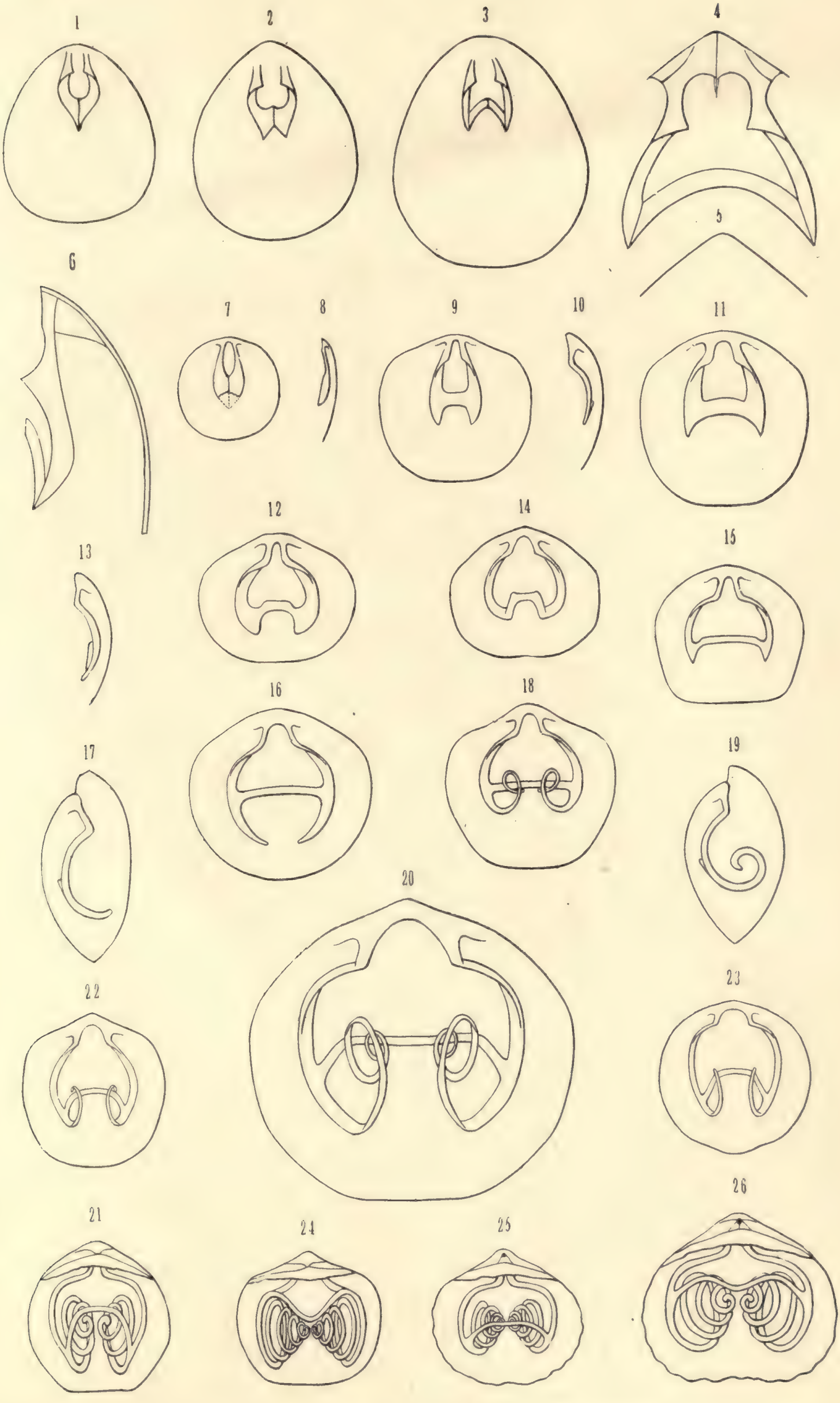
22.—The spirals and loop in (*Hallina* =) *Zygospira saffordi* W. and S. Trenton, *Tennessee.* × 6.

23.—The spirals and loop in (*Hallina* =) *Zygospira nicolletti* W. and S. Trenton, *Minnesota.* × 6.

24.—The spirals and loop in *Zygospira headi* Billings. (After Hall.) × 2.

25.—The spirals and loop in *Zygospira modesta* Say. (After Hall.) × 2½.

26.—The same. (After Davidson.) × 3½.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Brachail supports in Dielasma and Zygospira.

ON THE DEVELOPMENT OF THE SHELL OF *ZYGOSPIRA RECURVIROSTRA*.

BY CHARLES SCHUCHERT.

The material showing the ontogeny of the shell in *Z. recurvirostra* was gathered from some blue-green shales on St. Anthony hill, a suburb of St. Paul, Minnesota. This horizon is equivalent to the lower Trenton of New York. Some of the associated brachiopods are *Orthis testudinaria*, *O. meedsi*, *Plectambonites sericea*, *Strophomena scofieldi*, *Clitambonites diversa*, etc.

The youngest specimen observed (plate xi, fig. 1) has a length of .8 mm., and is elongate subtriangular in outline, biconvex, with the ventral valve a little the deeper; ventral beak acuminate, inclined posteriorly at an angle of about 45° to the plane of the valves; delthyrium triangular, as wide as long and devoid of deltidial plates. In the apical portion there is a short concave plate continuous with the walls of the delthyrium, but apparently not attached to the rostral cavity. The fold and sinus are faintly developed, becoming obsolete at about the center of the shell and are without plications. In other individuals of about the same size the sinus is occupied by three short plications and the ventral fold by two. In specimens of a somewhat larger growth these primitive plications are rapidly followed by a number of new ones along the entire anterior margin. The size of the shell at which they begin to develop is variable (compare figs. 2–5), being the earliest in the narrow depressed individuals (fig. 3) and latest in the rounder and more convex specimens (fig. 4). New plications are rarely interpolated, their number being increased as growth proceeds by the addition of others along the lateral margins of both valves. The plications remain simple throughout.

The smooth nepiastic stage gradually grows more and more rotund and subquadrangular in outline, and at maturity is plicated to the apex of the shell. The ventral beak, which is at first slightly recumbent (fig. 1*a*), becomes erect, and finally is strongly incurved over the dorsal umbo (fig. 9*a*). The large open delthyrium is gradually reduced in size by the introduction of deltidial plates which grow inwardly from the walls of the fissure, being wider anteriorly where they join, leaving in the apex an oval pedicle opening. As the beak incurves these plates become larger, stronger, and anchylosed along the median line, but at maturity are nearly completely hidden by the dorsal umbo. The pedicle opening at maturity (fig. 9) is through the acutely convex portion of the ventral umbo, and is comparatively smaller in size than during previous stages.

Growth Stages.—A well-preserved specimen of about 1.5 mm. length (fig. 10), shows three distinct stages of growth before the introduction of the plicated or specific period: *a*, the initial shell or protegulum, with both cardinal lines arched; *b*, a broad, oval stage, in which the ventral hinge areas on each side of the delthyrium first appear, followed by *c*, a subcircular form, with the beginning of the fold and sinus. It is either during stage *c* or *b* or both that the concave plate in the apex of the delthyrium is developed. During the next or fourth stage the first specific characters begin to appear, as shown by the plications, and also the first stage of the calcareous brachial supports.

Observations and Correlations.

The first or initial shell in *Zygospira*, as in other brachiopods' is the protegulum, which has been compared with adult *Paterina* of the Lower Primordial. In many inarticulate brachiopods it is known that the protegulum is followed by a nearly round *Obolella*-like inarticulate stage, but in all rostrate articulate species in which the second stage has been observed there appears the first articulation of the valves. The fold and sinus, along with a few rudimentary plications, are introduced during the third stage of *Zygospira*. This form of shell much resembles some primordial species which have been provisionally referred to *Camarella*. With but slight modifications in the convexity of the valves and the greater or less prominence of the fold and sinus, this form is repeated in a number of early Paleozoic genera of the suborders *Trullacea* and *Rostracea*, as primordial *Camarella* and many species of *Pentamerus*, *Zygospira nicoletti*, *Camarella bisculata*, *Dayia*, and the so-called *Waldheimias* of the Upper Silurian. It is therefore impossible to refer with certainty on the basis of external character alone any Lower Silurian brachiopod of this form to any family of the Rostracea or to any rostrate family of the Trulacea. The presence or absence of deltidial plates at maturity, however, at once indicates the subordinal position of any rostrate species. If the rudimentary concave plate in the apex of the delthyrial cavity of nepiastic *Zygospira* has any phylogenetic significance, it shows that those families having deltidial plates and no spondylium, the Rostracea, had their origin in the Trullacea, a suborder in which the concave plate or spondylium is functional as a muscular fulcrum. This has already been inferred to be the case on other grounds, as geological occurrence and complexity of structure. A plate similar to that in nepiastic *Zygospira* exists in *Gwynia*, *Cistella*, *Atretia*, and *Terebratulina*.

At the beginning of the fourth shell stage of *Z. recurvirostra* the species is recognizable as belonging to the suborder Rostracea and apparently most closely related to the Rhynchonellidæ. The calcareous brachial supports first appear in a specimen about 1.33 mm. in length. The species is then referable to the Ancylobrachia, having a loop very much like that of *Centronella*. This loop then passes through a series of metamorphoses, acquiring spirals when the shell is about 3 mm. in length.

The mature exterior characters of the more prominent species of *Zygospira* will next be considered. *Z. nicoletti* (figs. 11, 11*a*, 12, 12*a*), one of the oldest species, retains many of the characters of the earliest period of the fourth growth-stage of *Z. recurvirostra*, and therefore more nearly resembles in form the primitive stock which gave rise to *Zygospira*. In *Z. saffordi* (figs. 13, 13*a*) the plications are more numerous than in *Z. nicoletti*, but reach the posterior third of the valves, and the shell is also more convex. *Z. recurvirostra* is larger, more convex, with a greater number of plications, which originate at the apex of the valves, and the ventral beak is more strongly incurved than in the species mentioned. From *Z. recurvirostra* one line leads through *Z. uphami* and *Z. erratica* to *Z. headi*, comprising a group which continues to increase in size, gibbosity, striation, and in the obsolescence of the fold and sinus. In another phylum characterized by *Z. deflecta*, *Z. modesta*, *Z. cincinnatiensis*, and *Z. kentuckyensis*, the plications do increase in size but not in number, while the inconspicuous fold and sinus of *Z. recurvirostra* is gradually developed more and more strongly, so that when the extremes of both lines are compared (*Z. headi* and *Z. kentuckyensis*) very dissimilar exteriors are seen to have resulted from the same stock. *Zygospira* attained the greatest development in the Lorraine group of the Ohio valley. The species are usually very abundant in individuals, often forming groups several inches in diameter.

Explanation of Plate XI.

Figure 1.—Dorsal view of the smallest specimen observed of *Zygospira recurvirostra* Hall. The fold and sinus are just visible along the anterior margin of the shell. × 12.

2.—A later stage, where the deltidial plates have begun to develop. × 12.

3.—A specimen in which the plications are developed unusually early. × 12.

4.—A specimen of larger growth than figure 3, in which the plications are slow in developing. × 12.

5–8.—Different individuals to show the progression of growth in the deltidial plates and the extent of the plications over the umbones. × 12.

9.—A mature example. The pedicle foramen is posterior to the deltidial plates, encroaching on the umbone of the ventral valve. × 6.

1*a*–9*a*.—A series of profiles of the specimens, figures 1–9, respectively, showing the change in the convexity of the valves and the incurvature of the ventral beak.

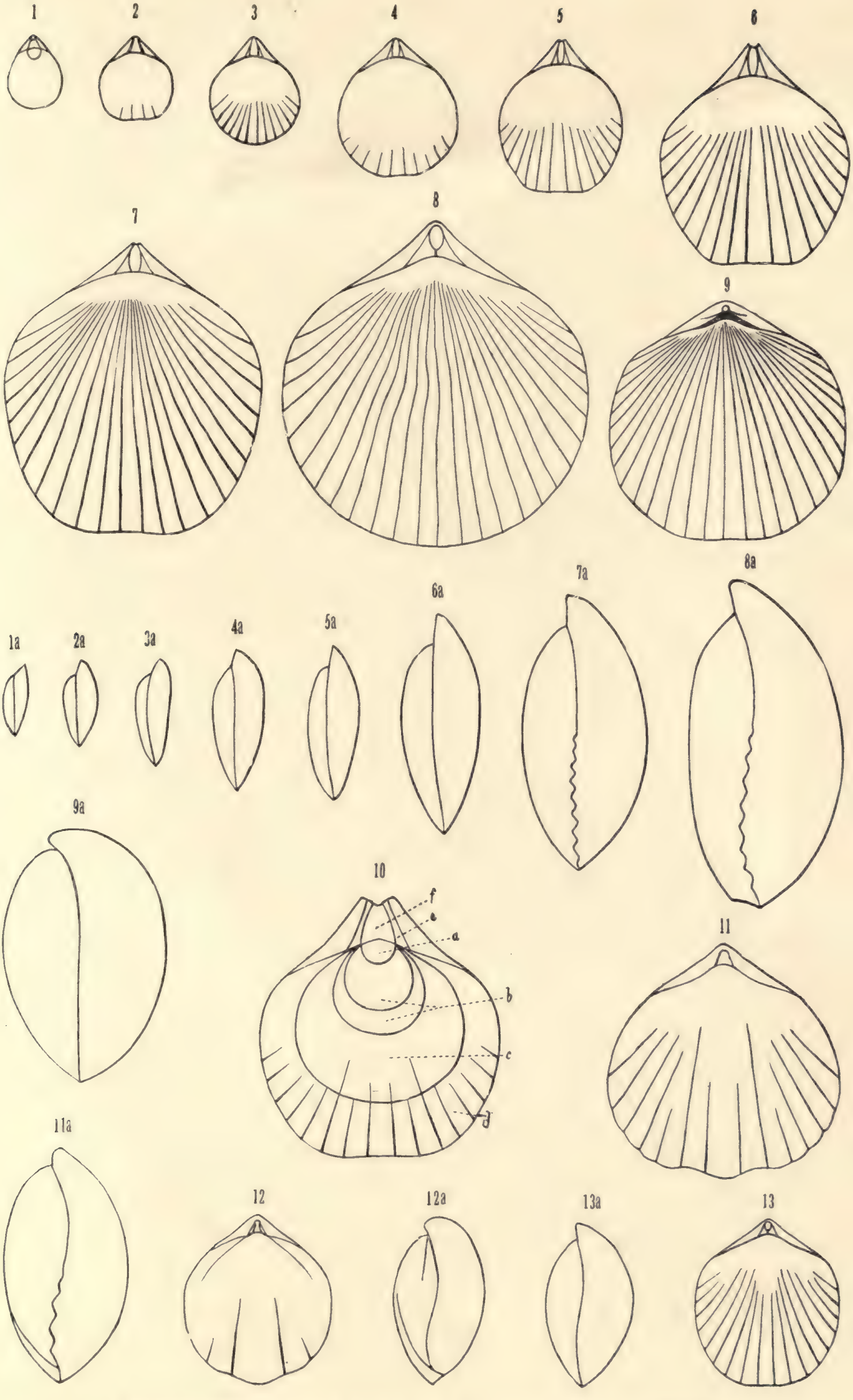
10.—A specimen preserving the lines of growth very clearly, of which the stronger ones only are figured. The apex of the ventral beak has been worn away by abrasion and resorption by the pedicle. *a*, protegulum; *b*, the first articulate stage; *c*, the stage in which the fold and sinus are developed; *d*, the plicated stage; *e*, deltidial plates; *f*, pedicle opening. × 25.

11, 11*a*.—An unusually large specimen of (*Hallina* =) *Zygospira nicoletti* W. and S., in which a few plications are developed on each side of the fold and sinus. × 6.

12, 12*a*.—Dorsal and profile views of one of the types of (*Hallina* =) *Zygospira nicoletti* W. and S., the form most commonly observed. × 6.

13, 13*a*.—Dorsal and profile views of the type of (*Hallina* =) *Zygospira saffordi* W. and S. This species is closely related to *Z. recurvirostra*. × 6.

Plate XI.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Development of the shell of Zygospira recurvirostra.

VOL. VIII, PP. 83-96 JULY 18, 1893

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

REDISCOVERY OF THE MEXICAN KANGAROO RAT, *DIPODOMYS PHILLIPSI* GRAY

BY C. HART MERRIAM, M. D.

WITH FIELD NOTES BY E. W. NELSON.

The first kangaroo rat known to naturalists was described by J. E. Gray, in 1841, under the name *Dipodomys phillipsi*.[*] Both species and genus were new, and were based on a single specimen presented to the British Museum by John Phillips on his return from Real del Monte, in the state of Hidalgo, Mexico, in the vicinity of which place it was supposed to have been obtained.[†] This specimen still remains unique, so far as authentic published records go, notwithstanding the fact that numerous museums in this country and Europe contain specimens labeled *D. phillipsi* which have been examined and treated as true *phillipsi* by nearly all writers on the genus during the past half century.

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[*] *Dipodomys phillipii* Gray, Annals and Magazine Nat. Hist., vii, Aug., 1841, 522. In the original article the name was spelled *phillipii* by typograpical error; it was corrected to *phillipsii* a few months later by the same author. (Am. Jour. Sci., xlii, 1842, 335.)

[†] Real del Monte is in the mountains at the extreme north end of the Valley of Mexico, about 50 miles northeast of the City of Mexico.

In studying a large series of kangaroo rats from Texas, New Mexico, Arizona, and California several years ago I was surprised to find that none of them conformed with the original description or with Audubon and Bachman's plate and measurements taken from the type specimen in the British Museum. It became apparent therefore that true *Dipodomys phillipsi* was not represented in the extensive collections examined, and probably was not an inhabitant of any part of the United States. Every available means was used to secure specimens from the supposed type locality, but without success. Letters were written in both English and Spanish to Mexican officials in Real del Monte describing the animal and offering a reward for a specimen, and later an experienced mammal collector was sent to the place, but with no better result. Finally Mr. E. W. Nelson, who has caught hundreds of kangaroo rats in various parts of the United States and Mexico and is thoroughly familiar not only with the habits of the animals but also with the kind of country inhabited by them, was requested to visit the region, in connection with his work for the United States Department of Agriculture. The result is a series of 67 handsomely prepared skins and skulls and several complete skeletons of the long lost *Dipodomys phillipsi*. Hence, after a lapse of more than fifty years, it is now possible for the first time to redefine the type of the genus and to differentiate the species from others with which it has been persistently confounded. Before doing this, however, it seems desirable to put on record with some detail the facts connected with its rediscovery and distribution.

Notes on a Search for Duplicate Types of Dipodomys phillipsi.

In response to my request, Mr. Nelson has contributed the following interesting account of his search for this species:

" After securing specimens of *Dipodomys phillipsi* in the Valley of Mexico, at Tlalpam, Ajusco, and Amecameca in December, 1892, and February, 1893, I finally set out to try and obtain specimens nearer Real del Monte, the supposed type locality. A long and careful search in the vicinity of Tula, in Hidalgo, just north of the valley, failed to discover it or any allied species. From that point to Pachuca, along the extreme northern border of the valley, the country presented the same hard, rocky, and unsuitable character found at Tula. Pachuca is situated at the extreme northeastern point of the Valley of Mexico, at the base of the Sierra de Pachuca, the latter forming the limit of the valley in this direction. At an altitude of about 9,000 feet, and about three or four miles in a direct line higher up in these mountains, lies the mining town of Real del Monte, the reputed type locality. The mountains are almost wholly composed of porphyry, with only a very scanty coating in places of a hard, clayey soil. A short visit to this locality was enough to show very conclusively that no species of this group had ever been taken in its immediate vicinity. A visit to the northern slope of the mountains near El Chico showed it to possess the same character.

"The next effort was made in the forlorn hope of finding the species about the border of the valley, at the base of the mountains, near Pachuca. A careful search of this vicinity for some miles in various directions failed to discover any sign of kangaroo rats or, indeed, any sufficient area of suitable ground. A trip was then made to the village of San Augustin, 18 miles south of Pachuca, in the Valley of Mexico, and this also resulted in finding the same rocky hills and hard clayey bottoms that prevail about the northern end of the valley.

"Giving up all hope of finding the species near Pachuca or Real del Monte—the alleged type locality—I decided to make another search for it at Irolo, which lies a little more than 25 miles south of Pachuca, in Hidalgo, and just east of the low divide which borders the Valley of Mexico on the east between the Sierra de Pachuca and the northern end of the Sierra Nevada de Iztaccihuatl. The course of the Vera Cruz or Mexican railway, on which I traveled, at first kept to the south near the west side of the divide. Some six miles out of Pachuca we passed over a narrow belt of softer soil than usual here, and I had hasty glimpses of several burrows among the maguey plants that I was quite certain belonged to some species of kangaroo rat. The road then left the divide and swung out into the Valley of Mexico, and the soil again became a hard clay. From the station of Ometusco, just within the Valley of Mexico, the road leads east for a few miles over a low dividing ridge to Irolo. About the latter place and away to the northward, toward the mountains of Pachuca, the bases of the low hills and ridges show pale yellow shades such as sandy deposits would give. A short search about the base of the hills near Irolo showed that areas of sandy and loose soil did in fact exist there.

"Further search showed that these areas of soft soil were occupied by kangaroo rats, which when captured, however, proved to be a 5-toed *Perodipus* instead of a 4-toed *Dipodomys*. No trace of any other species could be found, but the *Perodipus* was abundant.

"From the fact that the belt of country in which this species occurs at Irolo extends directly toward the point where I saw the signs on the road from Pachuca, with less than twenty miles intervening and a divide of not over 250 feet, I feel fully justified in assuming that the animals whose burrows were seen near Pachuca are a colony of the same species as that found at Irolo, namely, a *Perodipus*.

"On the other hand, the city of Tlalpam was the capital of the state of Mexico from 1828 to 1830, and from a much earlier period has been one of the important towns of the Valley of Mexico. This being the case, the abundance of *Dipodomys* in the sandy land at the very border of the town suggests the probability that a specimen taken there by an early traveler may have been the one brought to London by Mr. Phillips of Real del Monte, the erroneous reference arising from the notorious carelessness of the early collectors in labeling specimens." *

It should be added that Tlalpam is only about 60 miles from Real del Monte, and should be remembered that Gray did not say that his specimen came from Real del Monte, but merely that it was sent to the British Museum by "Mr. John Phillips, who has lately returned from Real del Monte"—quite another matter. The probability is exceedingly great that the specimen was not labeled at all before it entered the British Museum.

Geographic Distribution.

Mr. Nelson first found *Dipodomys phillipsi* at the extreme southern end of the Valley of Mexico and on the adjacent mountain slopes, where 28 specimens were obtained. Concerning its occurrence in this region he writes:

"These kangaroo rats occur in the bottom of the valley near Tlalpam, D. F., at an altitude of 7,500 feet, and at the eastern base of the main peak of Ajusco, near the village of the same name, at an altitude of something over 10,000 feet. Still further to the south, on the extreme border of the state of Mexico, adjoining Morelos, they were noted close to the peak of Huitzilac, near the Cruz del Marquez, at an altitude of 9,000 feet. They were also taken at the western base of Mt. Popocatapetl, near the village of Amecameca, at an altitude of about 8,300 feet. The peak of Huitzilac lies about 20 miles south of Tlalpam, and Amecameca is 28 miles east of the peak of Ajusco, thus giving the species a known range of less than 20 by 30 miles in this district.

"The animals were far more numerous near Tlalpam than elsewhere. This place is 9 miles south of the City of Mexico, at the extreme southern border of the valley, just where the first slopes of the Sierra de

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* In continuing my work to the eastward I found it necessary to visit the city of Puebla. There I learned that the State College had a small museum, which I visited. One of the first things that met my eye was a *Dipodomys phillipsi* labeled as coming from *Ojo de Agua, Puebla.* Leaving the city, my route took me first into Tlaxcala and thence to eastern Puebla, in both of which districts I found the species abundant, as detailed elsewhere in this paper.

Ajusco begin to form the mountain rim on that side of the basin. Lying just west of Tlalpam is a great lava bed, known as the *Pedregal*, which descends from the northern base of the peak of Ajusco and reaches down the slope and out along the southwestern border of the valley. The peak of Ajusco, rising to an altitude of 12,600 feet, lies about 9 miles in a southwesterly direction from Tlalpam. Commencing near the eastern base of this peak and following down the eastern border of the lava bed to the bottom of the valley at Tlalpam is a bed of fine, grayish volcanic ashes or sand. Originally this deposit of sand did not reach the bottom of the valley, but the heavy summer rains gradually washed it down until it is now spread for a mile or two out over the bottom, at the base of the hills extending east from Tlalpam. In this bed of fine, sandy soil, beginning almost with the last houses of the town, these kangaroo rats are very abundant. The ground occupied by them at Ajusco, Huitzilac, and Amecameca was once covered with pine timber, but is now used as corn or grain fields, and it is altogether likely that the distribution of the species in all of these localities from the border of the Valley of Mexico followed the subjection of the land to cultivation. At the present time, although there are large areas of apparently suitable land, its distribution is local and restricted to comparatively small districts."

At a later date Mr. Nelson found *Dipodomys phillipsi* on the plains of Puebla and thence northerly into eastern Tlaxcala and western Vera Cruz. Concerning its occurrence in this region he writes:

"The species was not encountered again until I reached the state of Tlaxcala. There, in the eastern half of the state, about the northern and eastern base of the Cerro de Malinche and the towns of Huamantla and San Marcos, it is common. Extending thence easterly along the same sandy plain into the state of Puebla, it is also very numerous.

"In this latter state the species reaches its extreme southeastern limit near the towns of Cañada Morelos and Esperanza. To the north of these localities it is abundant about the towns of San Adres, Chalchicomula, and up the adjacent western base of Mount Orizaba to an altitude of 9,000 feet. From these points it ranges across to Ojo de Agua and San Juan de los Llanos, in the same state. To the northeast its extreme limit is found about the northern and western base of the Cofre de Perote, a little east of the town of Perote, in the state of Vera Cruz. This gives the species a known range over parts of four states. It occupies the extreme southern end of the Mexican table-lands, and is therefore the extreme southern representative of the genus.

"So far as my observations have extended, this species is confined strictly to the areas of volcanic sand produced by two volcanic centers: *first*, the sandy belt lying between Mount Popocatapetl and the Cerro de Ajusco, some thirty miles in a westerly direction from the first-named peak, and all within the State of Mexico; *second*, the much larger district having its eastern border along the volcanic range from Mount Orizaba to the Cofre de Perote, and extending thence west to the eastern base of Mount Popocatapetl, crossing a small corner of Vera Cruz and all of the states of Puebla and Tlaxcala. Since the sandy plain of southern Tlaxcala and central and western Puebla as far as the eastern base of Popocatapetl is a continuation of the same character of country as that in which I have found the species in adjacent parts of these states, I have no doubt that further work will show it to be equally common in these unexplored districts. That the species ranges from Puebla and Tlaxcala northwesterly toward its reputed type locality in the Sierra de Pachuca is improbable, since a high pine-covered area separates the two districts.

"The presence of this species in Puebla and Tlaxcala adds considerably to the uncertainty attending the probable source of the type specimen. While Tlalpam was a well-known locality of early days in this country, it is to be taken in consideration that the regular highway (stage road) from Vera Cruz to the City of Mexico passed Perote and traversed a hundred miles of country where this species is very common. The vertical range of this species lies between 7,400 and 10,000 feet, but by far the greater number of individuals are found between 7,500 and 8,500 feet. Its center of abundance is in southeastern Tlaxcala and adjacent parts of eastern Puebla. Its extreme upper range, both at Ajusco and Mount Orizaba, is due to the animals following cleared fields up into the pines from their original lower range on the plains."

Habits.

Respecting the habits of *Dipodomys phillipsi* Mr. Nelson contributes the following, which, unless the contrary is stated, relates to the neighborhood of Tlalpam:

"Their little trails were to be seen after a calm night crossing the sand in every direction, forming in many places a perfect network. Each animal occupies a burrow having as a rule a single entrance, dug in the bare, open field. The holes enter the ground at a slight angle, and each has a shallow trough-like depression leading out from it for a few inches, as is customary with most members of the group. Ordinarily the trail leaving the burrow forks, forming a Y very close to the entrance, and each branch trail leads away across the sandy soil to a neighboring hole, or to a distance where it becomes lost among the scanty herbage, where the owner finds its forage of seeds and small succulent leaves. Here and there little cone-shaped pits, an inch or two deep, show where the inhabitants have dug up little plants or hidden seeds.

"When captured the animals frequently had their cheek pouches full of seeds and small green leaves or young plants. Judging from what I noted in this way, it was evident that quite a variety of small plants contribute to their food supply. At the four localities where they were found they were located in old grain fields and their burrows and habits appeared to be the same. In no instance was a group of holes noted, and it was rare to find two entrances to the same burrow.

"Except at Tlalpam, they were not found in considerable numbers in the Valley of Mexico, and were scattered. Wherever found they were always in very loose, sandy soil. At Tlalpam their burrows appeared to be shared by the little yellow pocket mouse (*Perognathus*), which was nearly as common as the *Dipodomys*.

"As usual in this group, these animals are strictly nocturnal, and judging from the number of tracks, they must be very active during calm nights, even when the temperature is some degrees below freezing. For one or two nights during a severe storm they do not venture out, but if the storm continues longer they forage enough to procure food. At Ajusco at rare intervals a foot or two of snow covers their haunts, and cold storms are common. Elsewhere in their range sharp frosts are common during the winter months.

"The preceding notes concerning the habits of this species, although written with particular reference to the south end of the Valley of Mexico, apply equally well to other parts of its range. In the eastern part of its range it frequents the same open sandy fields, but many of the holes were also found at the bottom of shallow ditches entering the ground at the foot of the low bank at the sides. Others were found similarly situated along the sides of small arroyos. In one field above Chalchicomula the holes entered the ground almost perpendicularly for five or six inches before sloping away at the usual slight angle. This was due, however, to the fact that the very loose sandy character of the surface soil made it impossible to start a hole in at the usual angle."

Identity of Nelson's Specimens with Dipodomys phillipsi Gray.

Apart from the geographic proximity of Real del Monte to the region where Mr. Nelson obtained his specimens, and wholly independent of the question as to whether or not the animals whose burrows were observed 6 miles south of Pachuca belong to the same species, or to the genus *Perodipus*, the specimens themselves afford positive proof that they are the species described by Gray as *Dipodomys phillipsi*, as may be seen from Gray's original and very circumstantial description, which is here reproduced entire:

"*A new Genus of Mexican Glirine Mammalia.*—Mr. John Phillips, who has lately returned from Real del Monte, Mexico, has, at the recommendation of Mr. John Taylor, sent to the British Museum the skins of some very rare and interesting birds, of a *Bassaris*, and of the new animal which I shall now proceed to describe. This animal is very interesting, as having all the external form and coloring of a *Gerboa;* and it is doubtless the American representative of that African genus, though differing from it very essentially in being provided, like some other American genera, as *Saccophorus*, *Saccomys*, and *Heteromys*, with large cheek-pouches, which open externally on the side of the cheeks. I propose to call it

"*Dipodomys.*

"Body covered with soft hair. Head moderate, with large cheek-pouches opening externally on the side of the cheeks. Ears and eyes rather large; the fore-legs short; the hind tarsus long and slender; the hind feet very long; the soles covered with hair; toes 5–4. The tail much longer than the body, covered with rather short hair, and with a dilated brush at the end; the upper cutting teeth grooved in front. Grinders—(?)

"This genus differs from all those above cited in the tail being elongated and covered with hair, with a pencil at the ends like the *Gerboas*, and from *Saccomys* in the soles of the hind feet being hairy.

"*Dipodomys phillipii Gray.*

"Gray-brown, with longer black hairs; sides sandy; sides of the nose, spot near the base of the ears, band across the thigh and beneath, pure white; nose, spot at the base of the long black whiskers, and at the base of the tail, black; tail black-brown, with the band on each of its sides and tip white; penis ending in a long spine. Length: body and head, 5 inches; tail, 6½ inches; hind feet, 1½ inch.

"Inhab. Mexico, near Real del Monte. John Phillips, Esq." (J. E. Gray, Annals and Magazine of Natural History, vol. VII, No. 46, August, 1841, pp. 521–522.)

By a fortunate circumstance Gray's type specimen was figured by Audubon in his colored plate (No. CXXX), which plate has the additional merit of tallying with the description and also with the specimens collected by Mr. Nelson.*

The measurements given by Gray (and repeated by Audubon) are: Head and body, 5 inches; tail, 6½ inches; hind feet, 1½ inches. Converted into millimeters, the length of the tail is 165, and of the hind foot 38. The averages of these measurements in 54 specimens collected by Mr. Nelson are: Tail, 167.5; hind foot, 41. In several individuals the hind foot fell to 39 mm. Mr. Nelson's measurements were taken in the flesh, which accounts for the slight difference in the length of the hind foot.

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* Audubon states: "Our drawing was made from a beautiful specimen in the British Museum, which was the first one brought under the notice of naturalists, and the original of Mr. Gray's description of this singular animal; it was procured near Real del Monte, in Mexico." (Quadrupeds of North America, vol. III, 1854, 140.)

In the light of the ample material collected by Mr. Nelson, the species may be redefined as follows:

Dipodomys phillipsi Gray.

Dipodomys phillipii Gray, Ann. and Mag. Nat. Hist., VII, 1841, 522. (Name spelled *phillipii* by typographical error and corrected to *D. phillipsii* by same author a few months later.—Am. Journ. Sci., XLII, 1842, 335.)

Macrocolus halticus A. Wagner, Wiegmann's Archiv für Naturgeschichte, 1846, 172–177 (from 'Mexico').

Dipodomys phillipsii Audubon and Bachman, Quadrupeds of North America, vol. III, 1854, plate (colored) CXXX (of Gray's type specimen), and pp. 137–140 in part.

NOTE.—The *D. phillipsi* of subsequent authors is composite and does not include this species at all.

Type Locality.—The Valley of Mexico, Mexico.

General Characters.—Tip of tail white; size, smallest of the species having this peculiarity (about equaling *D. merriami*, but tail longer); coloration very dark, resembling *D. californicus.*

Measurements.—Average of 23 adult specimens from Tlalpam and Ajusco, at the south end of the Valley of Mexico (measured in the flesh): Total length, 270 mm.; tail vertebræ, 168; hind foot, 41.

Color.—Upper parts sepia-brown, more or less suffused with ochraceous, and everywhere conspicuously mixed with black-tipped hairs; thigh patches large, becoming dusky, and forming a large black patch behind and on the sides of lower leg and ankle, reaching upper surface of heel; crescents at base of whiskers large, nearly black, and meeting across nose; eyelids black; supraorbital spot obscured; upper and lower tail stripes black, meeting along distal third, and succeeded by a short brush of pure white, usually measuring only 10 to 15 mm., thus being decidedly shorter than in any other white-tipped species.

Cranial Characters.—Skull slightly larger than *D. merriami*, but not so large as *D. californicus.* Viewed from above, the post-rostral portion of the cranium is subquadrate in shape, owing to the great breadth across the orbital bridges of the maxillaries, and the relatively slight development of the mastoids. The least interobital breadth of the frontals is greater than in any other species of the genus, equaling or exceeding the distance from the foramen magnum to the premolar, and considerably exceeding the length of the nasal bones. The tympanic capsule is produced anteriorly beyond the plane of the adjoining part of the mastoid, a condition not found in any other species except *D. merriami*, from which it differs in shape, being narrower and having the greatest projection on the inferior surface, while that of *D. merriami* is bluntly rounded anteriorly. The inflated mastoids are both relatively and actually smaller than in any other species and are separated on top of the skull by at least 3 mm. The forks of the supra-occipital enclose a broadly oval interparietal. The top of the skull is considerably arched both antero-posteriorly and transversely, the highest point being the middle of the fronto-parietal suture. The mandible is rather light and slender, and the angular processes are less strongly developed than in any other member of the genus.

Geographic Distribution.—The Valley of Mexico and adjacent mountain slopes on the south, and the plains of Puebla from Cañada Morelos and Esperanza north to Huamantla, Tlaxcala, and Perote, Vera Cruz.

Faunal Position.—From Mr. Nelson's account of the haunts of this species it appears to be an inhabitant of the Transition Zone (or perhaps of both the Upper Sonoran and Transition), in which respect it agrees with the California species which it most closely resembles (*D. californicus*), and differs from all others of the genus—the others being Lower Sonoran.

Variations in Dipodomys phillipsi.

The area inhabited by *Dipodomys phillipsi* is so small that the characters of the species are very constant, as would be expected. In 28 specimens from Tlalpam and Ajusco the length of the white tip of the tail, beyond the black hairs that overlap its base, varies from 5 to 15 mm.

The dark facial crescents and connecting band across the nose vary somewhat in different specimens from the same locality, but average much broader and blacker in those from the plains of Puebla than from the Valley of Mexico.

The tail averages shortest in specimens from Perote, Vera Cruz (163.4 mm.), and longest in those from Huamantla, Tlaxcala (175 mm.).

TABLE OF AVERAGE MEASUREMENTS,* RATIOS, MAXIMA AND MINIMA, AND PERCENTAGES OF VARIATION BY LOCALITIES, IN *DIPODOMYS PHILLIPSI* GRAY.

Localities.	No. of specimens.	Averages.			Ratios.		Maxima and minima.						Percentages of variation from mean measurements.		
		Total length.	Tail vertebræ.	Hind foot.	Ratios to total length.		Total length.		Tail vertebræ.		Hind foot.		Total length.	Tail.	Hind foot.
					Tail vertebræ.	Hind foot.	Max.	Min.	Max.	Min.	Max.	Min.			
Tlalpam, D. F., Mexico.	23	270	168	41.1	62.3	15.2	285	254	180	156	43.5	39	11.4	14.2	12.1
Chalchicomula, Puebla.	30	273.1	168.8	41	61.8	15	291	257	182	158	43	39	12.4	14.2	9.7
Huamantla, Tlaxcala . .	3	279.6	175	41	62.5	14.6	295	268	186	165	42	40	9.6	12	4.8
Perote, Vera Cruz.	5	264.4	163.4	40.7	61.8	15.3	280	255	174	158	41.5	40	9.4	9.7	3.6

* All measurements in millimeters.

Remarks on the Accompanying Table.

The table on the preceding page is believed to possess certain advantages over the ordinary method of tabulating measurements of mammals. It presents to the eye in the brief space of four lines a summary of the average measurements, ratios, maxima and minima, and percentages of variation, by localities, of 61 specimens, instead of covering a number of pages with the detailed measurements of each individual.

The usual object of measuring zoölogical specimens is to ascertain one or more of the following facts: (1) the normal* size of the animal; (2) the proportions (or ratios) of some of its parts, and (3) the limits or extremes of variation in a large series of individuals (which may be expressed both in actual maximum and minimum measurements and in percentages of the normal). The accompanying table not only summarizes this information for each locality in a single line, but also, by bringing into sharp contrast corresponding data from different localities, shows the amount of geographic variation in the species. Tables of the ordinary sort may contain the material from which these important facts can be ascertained, but the labor of digging them out from the bewildering mass of figures in which they are buried is so great that it is rarely undertaken.

Note on Macrocolus halticus Wagner.

A word is necessary, perhaps, concerning the *Macrocolus halticus* of Wagner,† which has been a stumbling block to naturalists for many years, though its true position was correctly indicated by Baird thirty-five years ago. Baird's remarks were as follows: "Although Wagner expressly states that there were no external cheek pouches in his specimen, and that in consequence it could not belong to Gray's genus, *Dipodomys*, yet the coincidence in every other respect—skull, teeth, skeleton, and external form—is so very intimate as to render it almost certain that the cheek pouches must have been overlooked, especially as we are particularly informed that the specimen was in very defective condition as preserved in alcohol. The species was probably identical with that described by Gray, viz: *D. phillipii*, which appears to be the one common in Mexico."* It should be borne in mind, however, that at the time Baird wrote (in 1857) all of the kangaroo rats were referred to *Dipodomys*, the genus *Perodipus* (containing the 5-toed species) not having been established until ten years later.† That Wagner's animal could not have been a *Perodipus* is clear from the statement that it had only 4 toes on the hind foot, and by other details of the original description. On the other hand, that it was a true 4-toed *Dipodomys* is shown by Wagner's original description, which includes a detailed account, with measurements of the skull and skeleton; ‡ by his drawing of the skeleton (natural size), published a little later,§ and by his drawings of the teeth, contained in the supplement to Schreber's Säugthiere (tab. 239, E.).

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* The normal of any measurement is the average or mean of that measurement in a large series of adult individuals from the same locality. In preparing such tables care should be taken to exclude all immature and imperfect specimens.

† *Macrocolus halticus* A. Wagner, Wiegmann's Archiv. für Naturgeschichte, 1846, 172–177.

The genus being disposed of, the species now comes up for determination. The fact that Baird referred it to *D. phillipsi* of Gray, in which he was followed by Coues, is of no weight, since both of these authors included under this head not only several very distinct species, but also species belonging to both genera. Nothing is known of the source of the specimen save that it came from Mexico. Three species of the genus are now known to inhabit Mexico, namely, *D. phillipsi*, *D. spectabilis*, and *D. merriami*. *D. spectabilis* may be at once eliminated because of its much larger size, leaving only *D. phillipsi* and *D. merriami* between which to choose. Wagner's measurements of the skull and skeleton give a total length of 269 mm. and a length of tail vertebræ of 168. His external measurements of the body and tail added together make a total of 279 mm., an excess of 10 mm. over the length of the skeleton, as usual when the body and tail are measured separately, the length of the body overlapping the point from which the tail measurement begins. Allowing

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* Baird, Mammals of North America, 1857, 409.

† Fitzinger, Sitzungsber. math.-nat. classe, K. Akad. Wiss. Wien, LVI, 1867, 126.

‡ *Macrocolus halticus* A. Wagner, Wiegmann's Archiv. für Naturgeschichte, 1846, 172–177.

§ Beitrage zur Kenntniss der Säugethiere Amerikas, II Abth., 1848, 319 und 332, pl. VII (Abhandl. d. II, Cl. d. k. Ak. Wiss V, Bd. II).

1 mm. for the thickness of the skin over the end of the nose, the measurements given by Wagner for the skeleton of his *Macrocolus halticus* (converted into millimeters) are: Total length, 270; tail vertebræ, 168; hind foot, 39.5. The averages of 23 adult specimens of *Dipodomys phillipsi* collected in the Valley of Mexico by Mr. E. W. Nelson are: Total length, 270; tail vertebræ, 168; hind foot, 41.1, the agreement being surprising. The measurements and description of the skull and skeleton also agree with those of *D. phillipsi* and not with *D. merriami* or any other species. The number of tail vertebræ is stated by Wagner to be 31. In two skeletons from Tlalpam the number is 32. No other species of *Dipodomys* is known to have more than 29, and no species of *Perodipus* more than 28. Furthermore, if additional evidence is needed, the drawing of the skull shows conclusively (if even approximately correct) that the animal is *D. phillipsi*, the interorbital breadth of the frontals being considerably greater than in any other species, and the mastoids being only slightly developed for a *Dipodomys*, the consequent breadth of the cranium across the mastoids but slightly exceeding the breadth across the maxillary bridges of the orbits.

It has been shown by the process of elimination that Wagner's animal could not belong to any known species other than *Dipodomys phillipsi;* and it has been shown by direct comparison of his description with duplicate types of the latter species that it does agree with this species in every particular. It seems safe to infer, therefore, that *Macrocolus halticus* of Wagner is *Dipodomys phillipsi* of Gray.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

THE PALEONTOLOGY OF THE CRETACEOUS FORMATIONS OF TEXAS.

THE INVERTEBRATE FOSSILS OF THE CAPRINA LIMESTONE BEDS.

BY ROBERT T. HILL.

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I.—STRATIGRAPHIC POSITION OF THE CAPRINA LIMESTONE BEDS IN THE COMANCHE SERIES.

About midway in the column composing the Comanche series or Lower Cretaceous of Texas, and constituting the uppermost member of the Fredericksburg division (Comanche Peak group of Shumard in part), there is a peculiar group of strata known as the Caprina limestone of Shumard.*

Dr. Shumard placed the bed in the Upper Cretaceous, at the very top of the whole of the fifteen or more subdivisions of the two great formations of Texas, instead of in the middle of the lower series, where it belongs. His original description of it is as follows:

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* First Annual Report Texas State Geological Survey, Austin, 1880–'88, pp. 124–126.

> *Caprina Limestone.*—This is the uppermost recognized member of the series and, although of no great thickness, has a somewhat extended geographical range. It is a yellowish-white limestone, sometimes of a finely granular texture and sometimes made up of rather coarse, subcrystalline grains, cemented with a chalky paste. It generally occurs in thick massive beds, and is capable of withstanding the action of the weather to a greater extent than most of the members of the Cretaceous system. This formation is usually found capping the highest elevations, and its presence may be nearly always recognized, even at a distance, by the peculiar flat-topped and castellated appearance it imparts to the hills. According to Dr. Riddell, it is finely displayed along the bluffs of Brazos river in Bosque, McLennan, and Hill counties; also along the Leon and Bosque rivers. The summits of the remarkable elevation known as Comanche peak, in Johnson county, and that of Shovel mountain, in Burnet county, consist of this rock. The fossils are chiefly Caprina, Cytherea, and Ammonites of undetermined species. (Trans. St. Louis Acad. Science, vol. I, 1860, pp. 583-584.)

In a previous paper the writer has described the Caprina limestone substantially as follows:

> *The Caprina Limestone.*—Without any serious stratigraphic break in the chalky limestones the abundant Comanche Peak fauna disappears and there continue 300 feet, more or less, of chalks and chalky limestones of varying degrees of consistency, from a pulverulent condition to firm limestones, which seem to be a secondary condition of the chalk produced by superficial hardening. These hard layers form the table rock of the buttes and mesas of the extensive Grand Prairie region and are exposed in the river bluffs between Austin and Mount Bonnell, on the Colorado, where the chalk has been more or less hardened into firm limestones by the local metamorphism accompanying faulting. The lime-kilns and quarries immediately west of Austin are all located on this subdivision.
>
> Accompanying these chalks and chalky limestones are well defined layers of exquisite flint nodules, occupying apparently persistent horizons in localities. The flint nodules are oval and kidney-shaped, ranging in size from that of a walnut to about two feet in diameter. Exteriorly they are chalky white, resembling in general character the flint nodules of the English chalk cliffs. Interiorly they are of various shades of color, from light opalescent to black, sometimes showing a banded structure. These flint nodules are beautifully displayed *in situ* in the Deep Eddy canyon of the Colorado, above Austin, where they can be seen occupying three distinct belts in the white chalky limestones.
>
> Where these chalky limestones form the basis of extensive plateaus, such as the remnants of the Grand Prairie west and southwest of Austin,

the flints are left in great quantities as a residuum of the softer chalks (which are more readily decomposed into soils and washed away), and they cover large areas of country. They have also been transported eastward in past geologic times by marine and river action, and are distributed over large areas along the margin of the Black Prairie region as a part of the Post-Cretaceous gravels of that region. In some of these flints remarkable decomposition is exhibited, the products being geode-like cavities lined with quartz-crystals and pulverulent substance.

These are the only flint horizons, so far, at least, as is known to the writer, in the whole of the immense Cretaceous deposits of the United States. They occur about the middle of the Lower Cretaceous series instead of at the top of the Upper series, as in England. It was from these flints that the ancient and modern Indians made their flint implements, and the ease of their lithologic identity will be of value to the anthropologist in tracing the extent of the intercourse and depredations of former Indian tribes inhabiting this region. Occasionally the flints, especially an opalescent variety in Comanche county, possess nuclei in the shape of fossils, usually *Requienia.*

The decomposition of these flints and of the adjacent limestones has produced some peculiar and unique effects in the rocks and landscape of the region, the silica replacing the calcium carbonate and leaving as a remnant a peculiar porous cavernous rock, usually of a deep-red color from the hydration of the iron pyrites into limonite, composed of the siliceous pseudomorphs of fossil *Rudistes* and other shells, the interstitial spaces glittering with minute quartz crystals which line them.

Immediately west of Austin, along the downthrow of the great Bonnell fault in the bluffs of the Colorado, another peculiar transformation takes place in the Caprina limestone. Occasional red decomposing spots occur in the massive white chalky limestones. Upon closer examination the apparently non-fossiliferous limestone is seen to be undergoing decomposition into a dry pulverulent inflorescence, and as a residuum there remains a dry red dust containing exquisitely preserved calcite pseudomorphs of many rare fossils, such as recently described by Roemer and White, the occurrence of which I have located in this horizon.

Traces of the following economic products have been discovered: Potash, salt, strontianite, anhydrite, epsom salts, gypsum, and gold, but in quantities as yet unknown.

At Austin a fault of about 750 feet downthrow has broken this limestone division into two different areas, and hitherto confused its measurement.

The limestones are more resistant to erosion than the over and under lying strata, and hence form the summit scarps and mesas of the peculiar buttes and divides in Hood, Comanche, Hamilton, Bosque, Coryell, Lampasas, and other counties of the Grand Prairie regions of Central Texas. It also occurs as the surface of extensive prairie regions in western Williamson county. It also caps the summit of the Jehosaphat plateau in northwestern Travis county, and the Edwards plateau to the south, where its surface outcrops, owing to rain sculpture, is weathered into extensive fields of "Karrenfelder" or miniature mountains.

The limitations of this group of strata have not been finally determined, but it should include as its upper members the Austin marble (the Upper Caprotina limestone and the lithographic flags of my local Austin section). No abrupt break is evident between these and the underlying beds which contain the Comanche Peak fauna of Shumard (Die Kriedebildungen bei Fredericksburg of Roemer). The detail of these beds at Austin have been given by Mr. J. A. Taff (who made the section under my supervision) in the Third Annual Report of the Texas Geological Survey.

Stratigraphically the Caprina limestone represents the culmination of the subsidence that progressed during the Comanche epoch.

Paleontologically the Caprina limestone beds are of the greatest interest. for in them we have the development of the aberrant *Chamidæ* and *Rudistes* of this country. They contain all the species of these families known to occur in the Cretaceous of the United States, with the two exceptions of the Caprotina-like *Coralliochama* of California and the large *Radiolites austinensis*-like forms so common in the equivalents of the Colorado group of the Upper Cretaceous in the Alabama, Texas, and Colorado regions. As it is clearly and distinctly overlain by the whole of the Washita division which corresponds to the Gault of Europe, as will be later shown by the writer, and is above the well-defined beds of the Trinity and Lower Fredericksburg division, it affords an important landmark in tracing the progress of marine life on this side of the ocean.

II.—CHARACTERISTIC FOSSILS.

The fauna of the Caprina limestone has been little understood, owing to the unfortunate fact that many of its fossils have been attributed to other horizons. Shumard* included the Lower Caprotina limestone of the Trinity division in Hood county with the Caprotina limestone of the Caprina beds, and throughout his valuable literature one fails to find any distinction between them. A few years since my friend, Mr. George Stolley, discovered a fauna in what is now known to be the Caprina limestone in the bluffs of the Colorado, a few miles west of Austin. Not knowing the horizon of these beds, he sent them to Dr. C. A. White, of the United States Geological Survey, and Dr. Ferdinand Roemer, at Breslau. Dr. White described several of the forms of aberrant *Chamidæ*, but owing to the lack of stratigraphic particulars he refrained from publishing any age conclusions.* Dr. Roemer published † beautiful illustrations of these fossils and described them with his accustomed skill, but at that time, not knowing the comprehensive character of the beds in the immediate vicinity of Austin and probably deceived by the lithologic resemblance of the matrix, he erroneously concluded that they came from the Austin chalk (Niobrara) of the Upper Cretaceous. His conclusions that the Austin chalk from which he supposed these fossils to have come was of Turonien age was undoubtedly correct. The Austin chalk abounds in many other species which justify such a conclusion, but not one of these species later described warranted such a conclusion, nor did they come from that horizon. The writer regrets that he is unable here to republish Dr. Roemer's excellent figures and descriptions of this fauna.

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*Loc. cit., p. 584.

The following is a list of the species which I have observed from the Rudistes horizon in the Caprina limestone beds at Austin, Texas:

- *Parasmilia austinensis* Roemer.
- *Pleurocora texana* Roemer.
- *Pleurocora coalescens* Roemer.
- *Cladophyllia furcifera* Roemer.
- *Coelosmilia americana* Roemer.
- *Holectypus* Roemer.
- *Pateila* or *Pileolus* (?).
- *Chrysostoma.*
- *Helicocryptus* or *Adeorbis.*
- *Ziziphinus* (*Calliostoma*).
- *Nerinea austinensis* Roemer.
- *Nerinea cultrispira* Roemer.

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* Bulletin 4, U. S. Geological Survey, on Mesozoic fossils, by C. A. White, Washington, 1884.

† Paleontologische Abhandlungen Herausgegeben von W. Dames und E. Kayser, Vierter Band. Heft 4. Ueber eine Durch die Haeufigkeit Hippuriten-Artiger Chamiden Ausgezeichnete Fauna der Oberturonen Kreide von Texas von Ferdinand Roemer. Mit 3 Tafeln. Berlin, 1888.

Nerinea subula Roemer.
Glauconia (?).
Cerithium obliterato-granosum Roemer.
Cerithium austinensis Roemer.
Trochus texanus Roemer.
Solarium planorbis Roemer.
Natica (Amauropsis) avellana Roemer.
Requienia patagiata Ch. A. White.
Monopleura marcida Ch. A. White.
Monopleura pinguiscula Ch. A. White.
Lucina acute-lineolata Roemer.
Requienia patagiata Ch. A. White.

The following forms have a more general occurrence:

Ostrea munsoni sp. nov.
Radiolites texana Roemer.
" *davidsoni* sp. nov.
Requienia texana Roemer.
Ichthyosarcolithes anguis Roemer.
Monopleura marcida Ch. A. White.
Ammonites (Buchiceras) pedernalis von Buch.
" *(Schloenbachia) acute-carniatus* von Buch.

In addition to the foregoing numerous species have been described under the generic name of *Caprina*, owing to the occurrence in immense quantities of a fossil supposed to have belonged to that genus. These fossils, however, are usually imperfectly preserved, but it can now be said with assurance that none of them belong to that genus, but are mostly *Ichthyosarcolithes* or *Radiolites*. All of the so-called Caprinas heretofore described from Texas come from this horizon.

Most of the Austin species occur in the bluffs of the south bank of the Colorado and Barton creek, just west of Austin, as beautifully preserved calcite pseudomorphs. Usually the limestone is very barren of all fossils except the *Rudistes* and *Chamidæ*.

Other aberrant *Chamidæ* and *Rudistes* from the Texas Cretaceous have long been known, but their exact stratigraphic range has not been clearly stated. With the exception of *Radiolites davidsoni* herein described, the stratigraphic occurrence of all the species was unknown to their authors when they described them. Many were described from imperfect specimens, and all the writers previous to Dr. White's valuable contribution expressed serious doubts as to the true generic position of the forms. It can now be said that, with the single exception of *Radiolites austinensis*, all of these forms in Texas come from the Caprina limestone. The following is a list of the forms thus far described:

CHAMIDÆ.

Diceras (*?*) Roemer.
Requienia bicornis Meek, 1876. Fort Lancaster, Texas.
 " *patagiata* White, 1884. Near Austin, Texas.
 " *texana* Roem., 1852; White, 1884. Near Austin, Texas. Highlands between New Braunfels and Fredericksburg. Marcou, 1858, reports this form at "Comet creek, on left bank of the False Washita."
Monopleura marcida White, 1884. Near Austin, Texas.
 " *subtriquetra* Roem., 1852. Valley of San Saba and upper arm of Pedernales river.
 " *pingiuscula* White, 1884. Near Austin, Texas.
 " *texana* Roem., 1852.
Ichthyosarcolithes anguis Roem., 1888, Barton creek, west of Austin.
 " (*?*) (*Caprina*) *crassifibra* Roem., 1849, 1852.
 " (*?*) (*Caprina*) *guadalupæ* Roem., 1849, 1852.
 " (*?*) (*Caprina*) *planata* Con., 1855. Oak creek, near Pecos, Texas.
 " (*?*) (*Caprina*) *occidentalis* Con., 1855, 1857. Pecos river near mouth. (A. Schott.)
 " (?) (*Caprina*) *texana* Roem., 1849.
Plagioptychus (*?*) *cordatus* Roem., 1888.

RUDISTÆ.

Radiolites (*Hippurites*) *texanus* Roem., 1849, 1852.
 " *davidsoni* sp. nov.

All of the above species occur in the Caprina limestone. *Radiolites austinensis* Roemer, is the only other form from the Texas Cretaceous. It occurs in the Austin chalk, and is so radically different in every aspect that it hardly belongs in the same group with the lower forms. With the exception of *Monopleura* and *Requienia*, which range downward into the Trinity Division, all the other genera occur only in the Caprina limestone, appearing suddenly upon the scene with these beds and completely vanishing thereafter.

Radiolites texanus Roemer, which comes from the Caprina limestone, was referred to the genus Hippurites by Roemer,* although upon reading his description as originally published it will be seen that he distinctly stated that it was exceedingly doubtful whether this form belonged to *Radiolites* or *Hippurites*. The name *Hippurites*, however, has gone forth in literature, and, inasmuch as this genus is a characteristic form of the Upper Cretaceous of Europe, its supposed occurrence in the Lower Cretaceous of Texas has been the greatest obstacle to man in accepting the lower position of the Comanche Series. I am now prepared to state that there is not a single *Hippurites* † in either the Lower or Upper Cretaceous of Texas, and that this unfortunate impression should no longer prevail.

III.—AGE OF THE CAPRINA LIMESTONE.

The writer does not feel prepared to separate the Caprina limestone from the remainder of the Fredericksburg Division as a unit for the discussion of homotaxy, and in the following remarks it should be remembered that the beds are stratigraphically related.

Dr. Fred. Roemer, in his classical monograph of the Kreidebildungen von Texas, placed the beds which are now known to be the Caprina limestone at the very top of the Texas Cretaceous and referred them to the Senonien. Forty years later he unknowingly described more of the fauna from the same beds and placed them in the Turonien.‡ In earlier writings I § have shown the erroneous impression under which Dr. Roemer thus placed these beds, and that instead of occurring above his Turonien (Austin chalk beds) they are stratigraphically below them, and hence could not be Senonien.

Shumard, who first defined and applied the present name to the beds whose fossils had been described in part by Roemer, also failed to discover the true stratigraphic position, and likewise placed them at the top of the Texas Cretaceous.||

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* Kreide, von Texas, p. 76.

† In the Third Annual Report of the Texas Geological Survey a species is mentioned by name only as "*Hippurites flabellata* sp. nov." from the Caprina limestone. No description whatever has been given of this form. From the writer's familiarity with the specimens in the Texas collection he thinks it probable that it must be a Radiolites.

‡ Paleontologische abhandlungen.

§ Am. Journ. Sci., vol. XXXVII, 1889, pp. 318–319. Ibid, April, 1893.

|| Loc. cit.

The writer has repeatedly shown that the stratigraphic position of the beds was in the middle of the Lower Cretaceous or Comanche series instead of at the top of the Upper, as believed by Roemer and Shumard, and hence, aside from the paleontologic evidence, he would assign these beds to a still lower horizon, probably the Uppermost Neocomian, or Transitional Neocomian-Gault, for the following reasons:

1. The fauna does not contain a single characteristic genus or species of beds of higher position.
2. The beds occur immediately beneath the Washita Division, which contain numerous species resembling those of the Gault of Europe.
3. The beds bear a remarkable paleontologic and stratigraphic resemblance to the Requienia Limestone beds of France and the Spanish Peninsula, where similar limestones, with *Radiolites* and *Requienia*, abound in the Upper Neocomian.

IV.—DESCRIPTION OF SPECIES.

Ostrea munsoni sp. nov.

Plate XII.

Compare *O. Joanæ* Choffat. Recueil de Monographies Stratigraphiques Sur le Système Crétacique du Portugal, par Paul Choffat. Lisbon, 1885, p. 34, plate 1, figs. 1–7.

Very thin and flat; elongately sub-triangulate and marked by many well defined radiating ribs; the pallial extremity rounded; beak more or less acuminate and slightly deflected, and evidently slightly attached; the inferior valve slightly concave, nearly flat, and showing near its beak an area of attachment. The larger valve flatly convexed and only slightly larger than the lower; the ornamentation of both valves is similar, and as remarked by Choffat in his description of *Ostrea Joanæ* a very similar form from Portugal, the two valves present an appearance as if they had been plicated together, the one upon the other. Each shell is very thin, and the living space small. When closed together the thickness of both valves is hardly one-twentieth the length of the shell.

The finely fluted ribs are slightly sinuous, continuous from beak to base or sometimes bifurcated, alternating with short ribs extending only half way from base. This is especially true upon the lower valve. This species is easily distinguishable from all the other North American oysters by its extreme flatness and thinness.

I have observed only a few specimens. These occur with great scarcity in the Caprina limestone, in association with *Radiolites davidsoni* at Belton and near Austin. The species is named in honor of Mr. T. V. Munson, of Denison, Texas.

This species resembles in general form the excellent figures of *O. Joanæ* Choffat, from the Cretaceous of Portugal.

Radiolites davidsoni sp. nov.

Plate XIII.

Description of Figured Specimen.—Very elongate, measuring over 40 centimeters; slightly flaring at larger end and gently tapering to small extremity; somewhat sinuous, pointed, and attached at lower end; exterior surface strongly marked by longitudinal ribs and grooves, as follows: Two especially broad and conspicuous grooves extending the entire length of the shell on opposite side to that shown in large figure, but seen in small segment and end view. These are accompanied by two large corresponding oblate ribs and a sharp, angular carina. These two grooves, ribs, and carina occupy one of the sides of the subtriangular circumference. The carina is very prominent and sharp, and extends from the smaller end to within about ten centimeters of the large extremity, where it becomes exfoliated and deflected like a mantle over and across the large ribs and grooves. This carina forms the upper margin of the large figure, and the angles seen in the cross-sections, and is opposite the smaller angle of the semi-lunate interior. It is bordered upon one side by one of the major grooves above described and upon the other by the somewhat flattened face shown in the figure of larger cross-section, on Plate XIII. The remaining two-thirds of the surface of the shell is marked by about fifteen small linear ribs, separated by wide, slightly concave depressions. Interior of shell a hollow cavity subpyriform or semilunate in cross-section, and marked by a few widely separated concave partitions occurring at intervals of three to five centimeters. Opposite the left hand major groove there is a slight projection extending the length of the interior which makes a narrow sinus in the casts when found. The interior is usually filled with calcite crystals.

Shell, irregularly thick, varying from three-quarters to one-half centimeter in different parts of the circumference. Outer surface is very smooth between the flutings and marked by fine cross-striæ, which are the exterior terminals of the circumscribant septæ of the honeycombed structure. The shell is composed of two layers (see fig. 1). The outer one (*a*) is very thick and constitutes most of the substance and has a fine cellular honeycombed structure. Cells very minute and rectangular in cross-section and produced by the intersection of the concentric and vertical laminæ. The imbricate concentric laminæ are arranged in successive layers diverging upward from the interior layer of the shell. The interior shell (*b*) is thin and very poorly preserved, being largely replaced by calcite crystals.

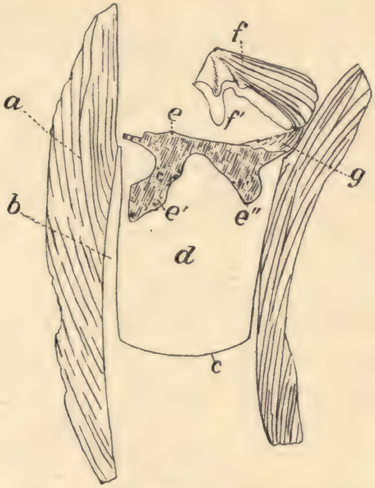


FIG. 1.—*Longitudinal section of larger extremity of specimen figured on plate xiii.*

a, outer shell of larger valve; *b*, space once occupied by inner shell of same; *c*, a cross-septum of interior cavity; *d*, last chamber of interior cavity; *e' e''*, calcified area, marking position of the muscular apophysis of upper valve; *f*, small fragment of upper valve; *f'*, section of outer edge of apophysis; *g*, undetermined fragment.

The opening of the shell is composed of the thin interior shell and a few layers of the exterior shell. Most of the concentric laminæ of the latter gradually disappear before reaching this termination. The dwelling chamber is about one and one-half centimeters deep, and the details of its structure somewhat concealed by the filled-in matrix. A longitudinal section of the large extremity (fig. 1) gives no detail of the anatomy of the living chamber, but gives some light on the upper valve.

Upper Valve.—No satisfactory specimen of the smaller valve has been found. In the specimen figured on plate XIII and in accompanying figure at *f* there is a fragment preserved, superficially resembling the shell of a Pecten, which, however, upon careful inspection appears to be a broken remnant of the smaller upper valve. It is composed of strongly radiating ribs alternating with finer lines, and in the longitudinal section shows a well-defined apophysis (*f*) corresponding to one of the casts preserved in the larger valve (e''). The section also shows distinctly the casts of the two muscular apophyses (e' e'') of the small valve, as in Radiolites.

The generic position of this form has been perplexing, and possibly it deserves a distinct generic position. That it is nearer *Radiolites* than *Hippurites* is clearly shown by the absence of many of the characteristic features of the latter genus, such as the numerous partitions which cross the interior cavity; the different structure of the dwelling-chamber, and the presence of only two instead of three longitudinal sutures. Upon the other hand, it possesses many of the distinguishing characteristics of *Radiolites*, such as the prominence of the two well-defined longitudinal sutures and the structure of the interior cavity. It also differs from the genus *Sphærulites*, which is characterized by one longitudinal suture. The cells are mostly rectangular, while of the genus *Radiolites*, according to Zittel, there are five or more sided. This distinction has been used by some writers to make new genera, but the writer prefers to defer such action.

The form occurs in great abundance in the limestones near the water's edge of the Lampasas and Leon creeks, in the eastern suburbs of Belton, Texas, from whence the type specimens were collected by Professor Wilson T. Davidson, in whose honor it is named. It is also abundant near Round Rock and Austin. There is a possibility that this species may be the same as the form entitled "*Hippurites texanus*" of Roemer, figured and described in Die Kriedebildungen von Texas, of Roemer; but however strong the inclination may be to think they are the same, his descriptions and figures are so radically different that they cannot be said to be identical.

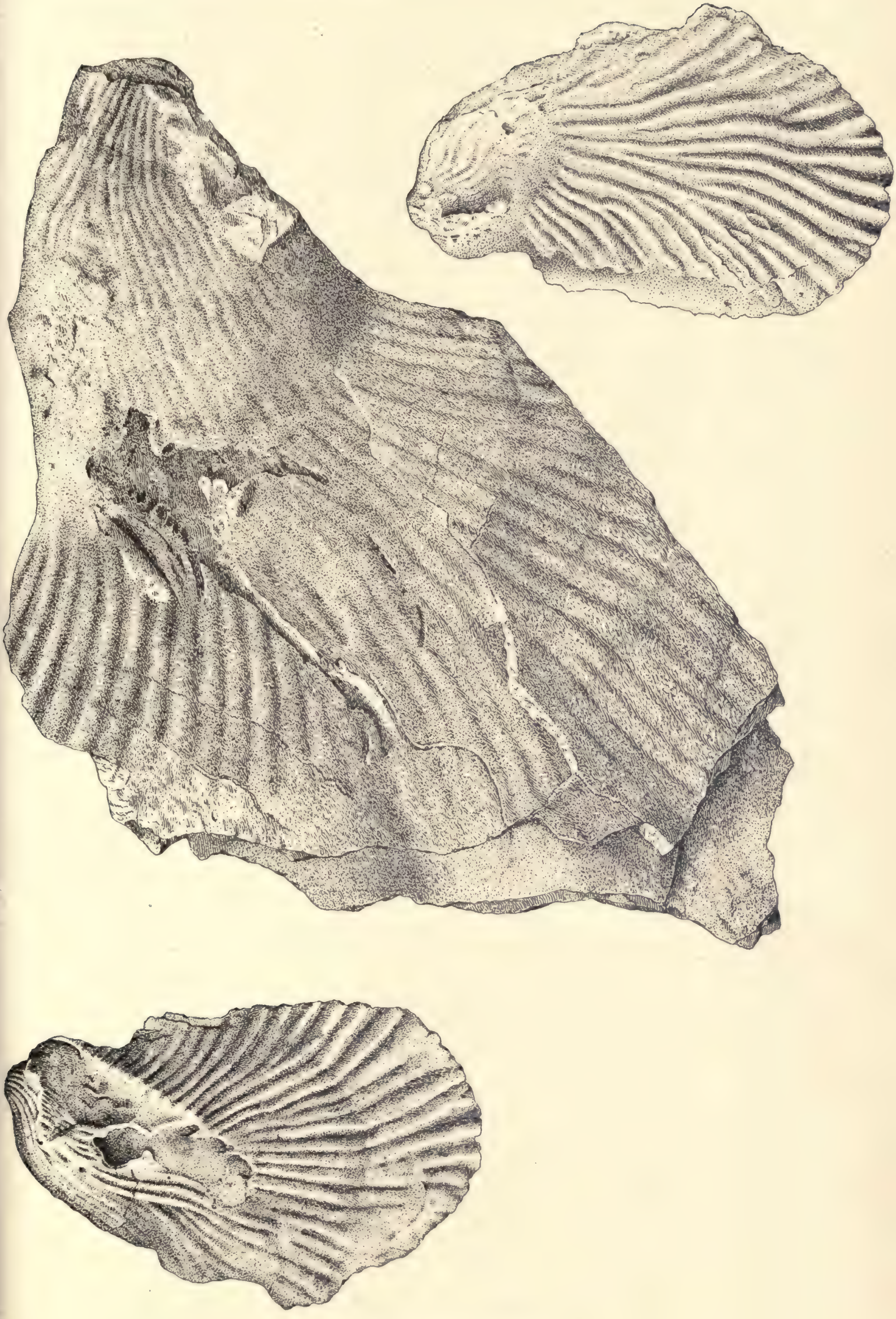
H. texanus, as figured, shows the cells to be polyginal instead of rhomboidal, as in *R. davidsoni*, and the surface grooving and cross-sections are entirely different in detail.

R. davidsoni shows great variation in length, some of the forms being very stunted and much thicker than the specimen figured.

Plate XII.

Ostrea munsoni sp. nov.

Three figures showing one view of an adult form and two views of medium-sized specimen. The older specimen shows larger valve on top exposing portion of lower valve at pallial margin. Both sides of the smaller specimen are shown, the smaller valve at the upper right-hand corner of the plate and the larger valve at the lower left-hand corner.



OSTREA MUNSONI sp. nov.

PLATE XIII.

Radiolites davidsoni sp. nov.

The illustrations show an elongated specimen with details of its general structure. In the lower right-hand corner is a figure showing the two main sutures, which extend the entire length of the shell, but are not seen in the large illustration. In the lower left-hand corner is an end view of the specimen figured. The object in the upper right-hand portion of this figure is a fragment of the broken upper valve.

PROC

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

TWO NEW WOOD RATS FROM THE PLATEAU REGION OF ARIZONA (*NEOTOMA PINETORUM* AND *N. ARIZONÆ*)

WITH REMARKS ON THE VALIDITY OF THE GENUS TEONOMA OF GRAY.

BY C. HART MERRIAM, M. D.

The two new mammals herein described are of unusual interest, not only because they are very distinct from any heretofore recognized, but also because they inhabit a region that has been pretty thoroughly explored during the past few years, and from which an unusually large number of mammals have been already described.*

One of the new species (*N. arizonæ*) presents a remarkable combination of the external characters of the bushy-tailed wood rats (genus *Teonoma* of Gray) with the cranial characters of the round-tailed species (*Neotoma* proper). The other (*N. pinetorum*), is a round-tailed species allied to the *N. fuscipes* group of California. Incidentally, the study of *N. arizonæ* led to the discovery of an important character that serves to distinguish *Teonoma* from *Neotoma*.

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*No less than twenty new species and subspecies were discovered in my biological survey of the San Francisco Mountain region in Arizona in 1889 (see N. Am. Fauna, No. 3. Sept., 1890); and others have been described from the same general region by Dr. Edgar A. Mearns and Dr. J. A. Allen.

Neotoma arizonæ sp. nov.

Type from Keams Cañon, Apache county, Arizona. No. $\frac{4249}{4980}$ ♀ ad. Merriam collection. Collected by J. Sullivan May 21, 1888.

General Characters.—Tail bushy as in *Neotoma cinerea*, but narrower; animal similar to *N. cinerea* in general appearance, but smaller, and agreeing with the round-tailed species in important cranial characters. Ears large, measuring about 34 mm. from anterior base; whiskers long and coarse, reaching shoulders. Total length about 365 mm.; hind foot about 35 mm. (in an old male from the same locality the hind foot measures 39 mm.). Except for its superficial resemblance to *N. cinerea*, this animal needs no comparison with any known species.

Color.—Upper parts everywhere bright ochraceous-buff, moderately mixed with black-tipped hairs; under parts and feet pure white. Tail bicolor: grayish brown above, white below.

Cranial and Dental Characters.—Skull smaller and much shorter than that of *N. cinerea*, with shorter nasals and nasal branches of premaxillaries, and larger and much more inflated audital bullæ. The most important cranial character, however, contrasted with *N. cinerea*, is the presence of a broad slit-like opening on each side of the presphenoid and anterior third of the basisphenoid, as in the round-tailed species generally. In the bushy-tailed *N. cinerea* this slit is completely closed by the ascending wings of the palatine bones. The molar teeth are actually as large as and relatively larger than in *N. cinerea*. The enamel pattern of the last upper molar is a nearly perfect trefoil, though the posterior reëntrant angle on the outer side is shallower than the anterior.

Variation.—The males are considerably larger than the females, and the young are gray in color, as usual in the genus. The Keams Cañon specimens are very uniform in color. An immature male from Tres Piedras, Taos County, New Mexico, collected by J. Alden Loring July 4, 1892 (No. 53016, United States National Museum, Department of Agriculture collection), has the upper parts gray, tinged with buffy-ochraceous, and the white of the under parts clouded posteriorly from the plumbeous of the under fur. A specimen from Fort Wingate, New Mexico, collected by Dr. R.W. Shufeldt (No. 3358 ♂, Merriam collection) is a little older, but evidently not adult. It has the upper parts more strongly suffused with pale ochraceous and the belly white. Its tail is less bushy than any of the other specimens examined. A young-adult female, collected at Winslow, Arizona, by Clark

P. Streator (No. 53517, United States National Museum, Department of Agriculture collection) has the under parts stained a deep salmon pink from the soil. This color washes out, leaving the belly pure white as in the Keams Cañon specimens.

Geographic Distribution and Faunal Position.—*Neotoma arizonæ* inhabits the Tusayan or Moki district in eastern Arizona, and adjacent parts of the Painted Desert on the west, and New Mexico on the east. In all, eleven specimens have been examined: eight from the Moki country, one from Winslow in the Painted Desert, one from Tres Piedras in northern New Mexico, and one from Fort Wingate, near the western border of New Mexico. The species evidently belongs to the Upper Sonoran zone.

Neotoma pinetorum sp. nov.

Type from SAN FRANCISCO MOUNTAIN, ARIZONA. No. $\frac{17692}{24628}$ ♀ ad. United States National Museum, Department of Agriculture collection. Collected by Vernon Bailey August 16, 1889 (original number, 366).

Measurements of Type Specimen (taken in flesh).—Total length, 355; tail vertebræ, 163; hind foot, 37; ear from anterior base, 25 (measured in dry skin). Average measurements of four adult specimens—total length, 362; tail vertebæ, 166; hind foot, 36.7.

General Characters.—Similar to *N. fuscipes* from southern California, but averaging slightly smaller; tail, ears, and hind feet shorter; tail more hairy; hind feet pure white [not clouded with dusky as in *N. fuscipes*]; back more strongly suffused with fulvous; whiskers long, reaching shoulders.

Color.—Upper parts fulvous, strongly mixed with black-tipped hairs; face from nose to above eyes gray, slightly grizzled, color of upper parts stopping at (or above) wrists and at ankles; under parts and feet white; tail sharply bicolor, above blackish, below white. Other specimens are less strongly fulvous, and the young are gray.

Cranial and Dental Characters.—Skull similar to that of the southern form of *N. fuscipes* but broader; brain case broader and shorter; palate and inter-pterygoid fossa longer; teeth larger (both molars and incisors).

General Remarks.—In my report on the mammals of San Francisco Mountain, Arizona, I referred the wood rat of the region to *Neotoma mexicana* of Baird.* At that time no typical specimens of *mexicana* were available for comparison. Since then, however, 14 specimens have been secured from the type locality, Chihuahua city, Mexico.

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* North Am. Fauna, No. 3, Sept., 1890, p. 67, pl. x, figs. 5–8 (skull).

On reëxamining the specimens from San Francisco Mountain and comparing them with the duplicate types of *N. mexicana* they are found to be widely dissimilar, not only in external appearance, but also in cranial and dental characters. Singularly enough, the new species resembles *N. fuscipes* of California much more closely than *mexicana*. It is an inhabitant of the pine belt at the base of the mountain, and therefore belongs to the Transition zone. Its range probably meets that of *N. mexicana*, which inhabits the adjacent Painted Desert on the east and the Grand Cañon of the Colorado on the north. The avenue by which its ancestors originally reached the pine plateau region of Arizona becomes a geographic problem of no little interest. Its nearest ally, the southern form of *N. fuscipes*, is closely restricted to California, and no member of the *fuscipes* group has ever been reported from the Rocky Mountain region.

Remarks on the Validity of the Genus Teonoma of Gray.

In 1843 J. E. Gray separated the bushy-tailed wood rats generically from the round-tailed species under the name *Teonoma*.* In this arrangement he was followed by Fitzinger in 1867†, but not by other writers. The only character ever assigned the genus *Teonoma*, so far as I have been able to ascertain, is its bushy-tail, in contradistinction to the short-haired terete tail of *Neotoma* proper. I take pleasure, therefore, in calling attention to an important cranial character which seems to have been overlooked. In the skulls of the round-tailed wood rats there is a long open slit on each side of the presphenoid and anterior third of the basisphenoid. These openings may be designated the *spheno-palatine vacuities*. In the bushy-tailed species (*Neotoma cinerea* and *N. cinerea occidentalis*) these vacuities are absent, being completely closed by the ascending wings of the palatine bones. Whether this character is of generic or subgeneric value may be left an open question for the present; that it is a character of considerable importance cannot be denied.

The most interesting feature connected with the new *Neotoma arizonæ* herein described is that while it agrees with *Teonoma* in the possession of a bushy tail, it has the spheno-palatine vacuities of *Neotoma* proper.

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* List of Specimens of Mammalia in the British Museum, 1843, p. 117.

† Sitzungsberichte Math.-Nat., Cl. K. Akad. Wiss.Wien, vol. LVI, Abth. I, 1867, p. 77.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

NOTES ON *THOMOMYS BULBIVORUS*.

BY GERRIT S. MILLER, JR.

Thomomys bulbivorus was accurately described by Richardson more than sixty years ago,* but has remained, save for this author's account, entirely unknown to naturalists almost to the present day. Richardson's description of *Diplostoma* (?) *bulbivorum* was based on a "Camas-rat" from the "banks of the Columbia," a region of which the mammalian fauna has until recently been very imperfectly known; hence it is no surprising circumstance that this gopher has been so long overlooked by collectors.

In the spring of 1890 Mr. A. W. Anthony took, at Beaverton, Washington county, Oregon, three specimens of *Thomomys* that soon after came into my hands and were immediately identified with the subject of Richardson's description. Lack of proper material to determine the questions of nomenclature raised by this discovery prevented any publication at the time, and the matter was allowed to rest. Recently, however, Dr. J. A. Allen, with an abundant supply of specimens at his command, reviewed a number of vexed questions concerning the synonomy of various species of *Thomomys*, and at his request the Anthony skins were placed at his disposal, the rediscovery of this long-lost animal being soon after announced,† while the

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*Fauna Boreali-Americana, I, 1829, 206.

†Bull. Am. Mus. Nat. Hist., v, 56, author's edition, published April 28, 1893.

Thomomys bulbivorus of Baird and subsequent authors was referred to the *Oryctomys* (*Saccophorus*) *bottæ* of Eydoux and Gervais.

Although the rediscovery of this fine gopher has thus been made known, it still remains to redescribe the animal, which I propose to do as follows:

Thomomys bulbivorus (Richardson).

Diplostoma (?) *bulbivorum* Richardson. Fauna Bor.-Am., I, 1829, 206, pl. xviiiB (lettered "douglasii" by mistake).

Thomomys bulbivorus Allen. Bull. Am. Mus. Nat. Hist., V, April 28, 1893, 56, pl. i, fig. 14 (skull).

Specific Characters. Largest known species of *Thomomys;* colors very dark; white markings about mouth extensive and in striking contrast; tail almost naked; skull exceedingly large and heavy.

Adult (♀ No. $\genfrac{}{}{0pt}{}{397}{225}$, collection of Gerrit S. Miller, Jr., Beaverton, Washington county, Oregon, May 5, 1890; A.W. Anthony, collector); dorsal surface mixed clove-brown and yellowish chestnut, the hairs everywhere slaty plumbeous at base, the three colors indescribably blended, but the clove-brown predominating on the head and mid-dorsal region though without forming a distinct dorsal stripe, this giving way on the sides to the chestnut, which in turn is replaced on the belly by slaty plumbeous; narrow ring around ear, muzzle, lips, outer edge of cheek-pouches, and ill-defined area extending thence to front legs very dark brown, almost black; linings of cheek-pouches and broad space between white, in striking contrast with surrounding color; a small white anal spot; dorsum of manus brownish, of pes white; a white tuft at proximal base of large tubercle on palm; tail very sparsely clothed on basal third with brownish hairs, which are not sufficiently numerous to conceal the skin; this in the dried specimen yellowish white, dark brown for 10 mm. at tip.

The three specimens differ but little among themselves in color, the variation, such as it is, being due to the varying amount of clove-brown in the fur of the back. This is a trifle less in the two males than in the female. In one of the males (No. $\genfrac{}{}{0pt}{}{399}{227}$) there is an indistinct wash of mars-brown on the belly. The dorsum of the right hind foot of No. $\genfrac{}{}{0pt}{}{398}{226}$ is covered with brown hairs. This, however, must be purely accidental.

Unfortunately the specimens were not measured in the flesh, but as they have been prepared with much care the following measurements taken from the dry skins are not without value:

No.	*Sex.*	*Date.*	*Length.*	*Tail.*	*Hind foot.*
$\frac{397}{225}$	♀	May 5, 1890..................	260	74	37
$\frac{398}{226}$	♂	May 12, 1890..................	280	73	41
$\frac{399}{227}$	♂	May 12, 1890..................	255	67	38

The longest hind foot among thirteen specimens of *T. bottæ* from Nicasio, Marin county, California, is 32 mm.; shortest, 28 mm.; average, 29.7 mm.

Thomomys bulbivorus differs from *T. bottæ* so greatly in color, as well as in size, that a detailed comparison of the two animals is scarcely necessary. In *T. bottæ* the prevailing tint throughout is wood-brown, more or less mixed with russet dorsally and blackening about the mouth, muzzle, and cheek-pouches. The latter are here, as in *T. bulbivorus*, lined with white; the area between, however, is usually dusky, sometimes more or less marked with white, but never, or at least very exceptionally, wholly white.

The skull of *Thomomys bulbivorus*, in addition to its very much greater size, differs from that of *T. bottæ* in many details of structure. The occipital portion is broader and flatter (ratio of height from inferior lip of foramen magum to mastoid width 50 in *bulbivorus*, 54 in *bottæ*) and the fronto-palatal depth proportionally greater. The dorsal aspect shows no decided points of difference, though in *T. bulbivorus* all ridges and muscular attachments are more strongly accentuated. Ventrally, however, important differences at once present themselves. That surface of the exoccipital which appears on the ventral aspect of the skull immediately laterad of the condyle is in *T. bulbivorus* occupied by a deep groove running obliquely to the axis of the skull, while in *T. bottæ* the surface is almost flat. The basioccipital is much broader in proportion to its length in *bulbivorus* than in *bottæ;* the audital bullæ of the former are much flatter and less inflated than in the latter. The form of the pterygoids differs markedly in the two species, those of *T. bulbivorus* being much the larger and strongly concave internally with hamulars converging at the tips, while in *T. bottæ* these bones are flat, with hamulars divergent posteriorly. Both foramen magnum and external nares are broader in proportion to their height in *T. bulbivorus* than in *T. bottæ.* Except in size, the mandibles and teeth of the two species show no distinctive characters.

The following table of cranial measurements and ratios of *Thomomys bulbivorus* and *T. bottæ* will serve to illustrate some of these differences in greater detail.

Cranial Measurements and Ratios of T. bulbivorus and T. bottæ.

	T. bulbivorus.			*T. bottæ.*			
Number	225	226	227	416	1183	1184	1187
Sex	♀	♂	♂	♂	♂	♂	♂
Basilar length	53	49	51	44	40.6	40	41.8
Basilar length of Hensel	50	46.2	48	41.6	38.2	37.8	39
Zygomatic breadth	39	......	35.5	30.6	29	28.4	27
Mastoid breadth	32.4	29.8	30	24	21.4	22	22.2
Interorbital constriction	7.2	7.8	7.4	6.8	6	5.4	6
Greatest length of nasals	21	18.2	20	16.8	15.8	15	15
Incisor to molar (alveoli)	23	21	22.2	18	16.6	16	17
Incisor to post-palatal notch	35.4	33.2	35.4	29	27	26	27
Height of crown from inferior lip of foramen magnum	16	15	15.4	13	12.2	12	12.2
Fronto-palatal depth at middle of molar series	23.4	21.5	22.4	17	16.4	16.2	16.6
Height of foramen magnum	6	6.4	6.4	6	5.8	5.8	6.2
Width of foramen magnum	7.8	7.8	7.4	5.2	5.4	5.2	5.2
Greatest length of basi-occipital	11.6	11.6	11	10.4	9.8	9.6	9.8
Greatest width of basi-occipital	11	11.2	10.6	8.2	8	8.2	8.6
Length of maxillary molar series on crowns	10	8.6	9.8	8.4	8	8	7.4
Length of maxillary molar series on alveoli	11	10.4	11.4	9.2	9	9	8.4
Greatest length of mandible	37.2	42.4	40	33.6	30.2	31	31.4
Length of mandibular molar series on crowns	9	9.4	9.6	8.8	8	8.4	8.2
Length of mandibular molar series on alveoli	10.4	11	11	10.2	9	9.2	9
Ratios to basilar length of Hensel—							
Of zygomatic breadth	78.00	......	73.95	73.55	75.91	75.13	69.23
Of mastoid breadth	64.80	62.55	62.50	57.69	56.02	58.20	56.92
Of fronto-palatal depth	46.80	46.53	46.60	40.86	42.93	42.59	42.56
Of occipital depth	32.00	32.46	34.41	31.25	31.91	31.74	31.28
Of nasal bones	42.00	39.39	41.60	37.98	41.36	39.41	38.46
Of maxillary molar series (crowns)	20.00	18.61	20.41	21.92	20.94	21.21	18.97
Foramen magnum: ratio of height to width	76.92	82.05	87.56	115.38	107.40	111.53	119.34
Basi-occipital: ratio of length to breadth	105.45	103.57	103.77	126.82	122.50	117.07	119.23

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PROCEEDINGS

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BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTION OF A NEW SPECIES OF *LAGOMYS* FROM ALASKA.*

BY E. W. NELSON.

Lagomys collaris sp. nov.

THE COLLARED PIKA.

Lagomys princeps Nelson and True, Report upon Natural History Collections in Alaska, pp. 273, 274, 1887 (not Richardson).

Type collected about 200 miles south of Fort Yukon, Alaska, near the head of the Tanana river. No. $\frac{14384}{36297}$. U. S. National Museum. Collected by E. W. Nelson, 1880. (Original No., 164.)

Distribution.—Mountains south of Fort Yukon, about the head of the Tanana river, to the Chigmit mountains, near the head of Bristol bay, Alaska.

Among the mammals secured by me in Alaska were three specimens of *Lagomys* which appear to belong to an undescribed species. They were obtained, at my request, through the kindness of Mr. L. N. McQuesten, from the mountains south of Fort Yukon, by the Indians of that district.

Mr. McQuesten informed me that the Indians report these animals as common everywhere in the highest ranges south of Fort Yukon, where they are usually found above timber line. From native accounts their habits appear to be identical with those of the more southern species. I showed the skins to a furtrader who had lived for many years at Kolmakovsky Redoubt, on the Kuskoquim river; he recognized them at once, and told me that the species is common in all of the high mountains of the Alaskan range south of the Kuskoquim as far as the base of the peninsula of Alaska. In confirmation of this reported range are two skins, now in the United States National Museum, taken in the winter of 1882, in the Chigmit mountains near the head of Bristol bay, by Mr. McKay, which, though in shabby condition, appear to belong to the same species. The three skins secured by Mr. McQuesten were taken by the Indians during a summer hunt, and are presumably in summer pelage, although possibly taken in spring, before the molt.

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* Presented at a meeting of the Biological Society of Washington, December 2, 1893.

The Chigmit Mountain specimens are in winter fur, and are much more ashy than those from the type locality.

The species thus has a known range from the high mountains south of Fort Yukon, in about latitude 65°, southwesterly to the vicinity of Bristol bay. Its northeast limit along this line coincides with the same limit of *Mazama montana*, and here occupies the southern part of the range of *Ovis dalli.* Its eastern extension remains a matter of uncertainty, but the type locality of Richardson's *L. princeps* makes it probable that *collaris* does not reach eastward to the mountains about the head-waters of the Mackenzie. That it does not range north of the Kuskoquim, along the course of that stream, was pretty definitely determined by my work in that region.

Description.—The dorsal surface, including top and sides of the head, is of a nearly uniform dark or grizzled-gray, with a dull yellowish wash on the crown and back. On the back and sides of the neck the yellowish wash is nearly or quite lacking, leaving a broad collar of dull iron-gray separating the yellowish-shaded areas of the head and back. This yellowish wash is much more apparent on the crown and middle of back and fades out at the sides, so that next the border of the white lower surface the color becomes ashy-gray. Just behind each ear is a small area of dull, light ashy. Below, a triangular white area occupies the entire chin and throat, with its apex in front. At each of the two posterior angles of this area is a yellowish spot forming a slight backward continuation of the light area of the throat at these points. These spots lie on the sides of the throat below and a little behind the ears. The white-throat area is well defined, and is succeeded by a distinct band of dull gray, which forms the lower part of the cervical collar. The remainder of the lower parts are pure white, including the feet and legs, except only the smoky-brown fur on the soles of the hind feet. The fore feet and legs to well above their insertion are included within the pure-white area of the lower surface. The exposed portion of the interior of the ear-conch is covered with a strong growth of coarse hairs. These hairs are pale gray at base, shading into yellowish toward the distal third, and the remainder of tip shiny black. The distribution of the hairs is such that the colors form a distinct yellowish band across the middle of the ear, succeeded by a very distinct black bar that extends along the edge and, at first glance, appears to form a black band bordering the ear. A close examination, however, shows that behind this black bar the actual margin of the ear is very narrowly edged with pale grayish-white. The black bar is about 3 mm. in width, and is distinct in all the specimens examined. The under fur of the dorsal surface is slaty-black. Above this slaty-black area the longer hairs have a narrow band of pale gray shading into a broader zone of dull yellowish, followed by a distinct black tip.

The two winter specimens from the Chigmit mountains are without any of the yellowish wash of the skins from the type locality, and the long hairs are mainly pale ashy with faint blackish tips, so that the color is a pale ash-gray. The still paler collar separating the uniform color of head and back is present, as is the dull-gray band across the neck below; otherwise they are colored similarly to the type specimen. All of the specimens have very long pelage as compared with the southern species, and this is especially noticeable in the three specimens from south of Fort Yukon, on which the long dorsal hairs reach an average length of over 22 mm.

Measurements.—The following average measurements in millimeters of five dried skins are given merely to serve as an approximation to the true dimensions: Total length, 182; hind foot, 28.3; ear, 19.1 (measured from anterior base).

Compared with *L. princeps* from Idaho and *L. schisticeps* from the Sierra Nevada of California, the following are the most striking external differences: The hairy, strongly marked ears of the Alaskan animal are conspicuously different from the two southern species, both of which latter have the ears thinly covered in front with very short hairs and a much more conspicuous whitish border. On both *schisticeps* and *princeps* the yellowish or fulvous wash of the upper surface becomes most distinct along the sides bordering the white lower surface, while in *collaris* it is absent in this region and is most conspicuous on the upper surface of head and back. There also appears to be a higher upward extension of the lower white area along the sides of the latter species. The plain gray of the collar below on the Alaskan animal is replaced on the other species by a band of fulvous or yellowish, which is inclined to spread over the adjoining parts and commonly shades nearly or quite all of the lower surface. There is no sign of this in any of the five specimens of *collaris* examined by me. The uniform coloration of the upper surface of the head and back, separated by a differently colored collar, is another marked characteristic of *collaris*.

Contrasted with *L. princeps* and *L. schisticeps*, the most conspicuous cranial character of *collaris* is the much larger size of its audital bullæ. They appear to be larger in every dimension than in the other two species.

The post-palatal notch is broad, as in *schisticeps*, but the palatine bridge is broad and heavy and slightly concave on both borders. The interorbital width is greater than in *schisticeps*. The infra-condylar notch of the mandible is more deeply excavated than in either of the other species. In addition, the angular process is much more strongly upturned and ends in a sharp point rising vertically behind the concavity of the notch. The horizontal ramus of the mandible is slenderer than in *schisticeps* and much as in *princeps* from Idaho.

To the kindness of Mr. F. W. True, Curator of Mammals in the United States National Museum, I am indebted for the opportunity to examine the material on which the present paper is based.

Skull measurements of three specimens of Lagomys collaris from the type locality, two hundred miles south of Fort Yukon.

U. S. National Museum number	36297	36298	36296
Basilar length of Hensel	?	35.5	?
Greatest zygomatic breadth	21.5	21.5	?
Interorbital constriction	5.25	5.5	5.5

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

JUNCUS MARGINATUS AND ITS VARIETIES.*

BY FREDERICK VERNON COVILLE.

Juncus marginatus has long been known as a species well distinguished from all others, but widely variable within its own limits. Writers on American botany in the early part of the present century gave different names to various forms of the plant, and not until 1866, when Dr. Engelmann published the first part of his Revision of the North American species of the genus Juncus, were they comprehensively treated as forms of *Juncus marginatus*.

The examination of the literature of *Juncus marginatus*, together with a large series of specimens, has brought the writer to separate the species into three forms, namely, *Juncus marginatus* (type form), *Juncus marginatus aristulatus*, and *Juncus marginatus setosus*, which may be presented as follows:

Juncus marginatus Rostk.

Juncus marginatus Rostk. Monog. Junc. 38, t. 2, f. 3 (1801). Type specimen from Pennsylvania.

Juncus cylindricus Curtis, Amer. Journ. Sci. xliv. 83 (1843). Type specimen from Lincolnton, North Carolina.

Juncus marginatus vulgaris Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type locality not given.

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*Presented at a meeting of the Biological Society of Washington, December 2, 1893.

Juncus marginatus paucicapitatus Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type specimen from Long Branch, New Jersey.

Stems in close tufts, seldom exceeding 50 cm. in height; leaf blades 1 to 2.5 mm. broad; inflorescence commonly bearing 5 to 15 heads; heads usually 5- to 10-flowered; inner perianth parts broadly obtuse; seed narrowly oblong, 0.4 to 0.5 mm. in length, short-stalked at the base, attenuate-apiculate at the apex, marked with 12 to 16 conspicuous longitudinal costæ, the intercostal spaces minutely and closely translineolate, usually with an occasional transverse line similar to the costæ.

Specimens examined:

Ontario: Near Sandwich, J. M. Bigelow, September 2, 1866.

Maine: York, M. L. Fernald, July 16, 1891; Cumberland, J. Blake.

New Hampshire: East Jaffrey, Walter Deane, July 17, 1889.

Massachusetts: Ipswich, William Oakes; South Framingham, E. L. Sturtevant, 1890; Cambridge, M. L. Fernald, September 11, 1891; Chelsea Beach Island, William Boott, September 10, 1853.

Connecticut: Plainville, J. N. Bishop, 1888.

Rhode Island: Providence, George Thurber, June, 1845.

New York: Mariners Harbor, Staten Island, Arthur Hollick, September 5, 1886; Pine Plains, Lyman Hoysradt.

New Jersey: Long Branch, C. W. Short, 1856.

Pennsylvania: Lancaster county, T. C. Porter, July 31, 1886; Germantown, Thomas Meehan, 1867; Grays Ferry, Philadelphia, C. E. Smith; Wysox, John Carey, 1841; Westmoreland county, P. E. Pierron, August 11, 1866; Chester county, W. M. Canby, July, 1866; Tinicum, Bucks county, T. C. Palmer, August, 1892.

Delaware: W. M. Canby; Newcastle, Alexander Commons, 1866.

Illinois: Athens, Elihu Hall, 1864; Beardstown, C. E. Geyer.

Kentucky: Lexington, C. W. Short, 1835.

Missouri: Carter county, B. F. Bush, July 21, 1891.

District of Columbia: Near Washington, L. F. Ward, July 9, 1876, June 23, 1878, July 21, 1878, and June 14, 1879; Washington, M. S. Bebb, 1864.

Virginia: Between Princess Anne and Berkeley, A. A. Heller, No. 1074, July 13, 1893; along New River, Carroll county, altitude, 2,200 feet, J. K. Small, July 12, 1892; Colonial Beach, F. V. Coville, July 6, 1890; Ocean View, Norfolk county, F. V. Coville, June 21, 1890,

North Carolina: Lincolnton, Lincoln county, M. A. Curtis; near Salisbury, Rowan county, A. A. Heller, June 21, 1890; Carolina Beach, New Hanover county, F. V. Coville, June 27, 1890.

Florida: A. W. Chapman; Duval county, A. H. Curtiss, No. 2975 in part.

Juncus marginatus aristulatus (Mx.).

Juncus aristulatus Mx. Fl. i. 192 (1803). Type specimen from either the Carolinas or Georgia.

Juncus aristatus Pers. Syn. Pl. i. 385 (1805). Type specimen the same as that of *Juncus aristulatus.*

Juncus biflorus Ell. Bot. i. 407 (1817). Type locality, ten miles from Savannah, on the road to Augusta, Georgia.

Juncus marginatus odoratus Torr. Fl. Nor. U. S. i. 362 (1824). Type specimen from "Bloomingdale, near New York."

Juncus heteranthos Nutt. Trans. Amer. Phil. Soc. new ser. v. 153 (1832–37). Type specimen collected along the Arkansas River.

Juncus canaliculatus Liebm. Mex. Junc. 43 (1850). Type specimen collected near San Antonio Huatusco, in the state of Vera Cruz, Mexico, at the altitude of 1,370 meters.

Juncus odoratus Steud. Syn. Pl. Glum. ii. 304 (1855). Type locality the same as that of *Juncus marginatus odoratus.*

Juncus marginatus biflorus Engelm. Trans. St. Louis Acad. ii. 455 (1866). Type locality the same as that of *Juncus biflorus.*

Stems single or in loose tufts, usually exceeding 50 cm. in length; leaf blades 1 to 5 mm. broad; inflorescence usually bearing 20 to 100 heads, in depauperate plants sometimes fewer; heads usually 2- to 5-flowered, becoming occasionally 10-flowered; inner perianth parts broadly obtuse; seed as in the type form, but 0.5 to 0.6 mm. long.

Specimens examined:

New York: New York, at Bloomingdale, John Torrey.

New Jersey: Near Atsion, C. F. Parker, July 31, 1866; near Princeton, John Torrey, July, 1830; Burlington county, C. F. Parker, August 19, 1867; Dennisville, Cape May county, C. F. Parker, July 15, 1866.

Pennsylvania: West Chester, William Darlington, 1827.

Delaware: Ellendale, W. M. Canby, September 16, 1891; near Wilmington, Alexander Commons, July 7 and 24, 1866.

Maryland: Garrett county, J. D. Smith, July, 1879; Salisbury, Alexander Commons, July 27, 1865; Salisbury, W. M. Canby, June, 1864.

Virginia: Virginia Beach, Princess Anne county, Arthur Hollick and N. L. Britton, September 26 and 27, 1890; near Virginia Beach, A. A. Heller, No. 1053, July 12, 1893; Colonial Beach, F. V. Coville, July 6, 1890; Ocean View, Norfolk county, F. V. Coville, June 21, 1890.

District of Columbia: Near Washington, Lester F. Ward, July 21, 1878.

North Carolina: Wilmington, M. A. Curtis; near Wilmington, F. V. Coville, June 26, 1890.

South Carolina: Aiken, H. W. Ravenel, June 12 and 25, 1866, and August, 1869.

Florida: Duval county, A. H. Curtiss, No. 2975, in part; Fort Meade, Polk county, J. D. Smith, March, 1880; Gadden county, A. W. Chapman.

Alabama: Alexander Winchell, No. 162; Montgomery, Gerald McCarthy, 1888; Fly Creek, Baldwin county, Charles Mohr, June 13, 1890.

Mississippi: Starkville, S. M. Tracy, Nos. 1420, 1421, June 20, 1890; Ocean Springs, S. M. Tracy, No. 1648, July 10, 1891.

Louisiana: Josiah Hale.

Texas: Hardin county, G. C. Nealley, 1888; Houston, F. Lindheimer, 1842.

Michigan: Near Fort Wayne, J. M. Bigelow, July 28 to September 9, 1866.

Kentucky: Lexington, C. W. Short, 1835.

Kansas: Cherokee county, W. S. Newlon, 1893.

Missouri: St. Louis, C. A. Geyer, May, 1842.

Arkansas: F. L. Harvey, 1882 to 1884; Little Rock, H. E. Hasse, May 25, 1886.

Indian Territory: Choctaw agency, J. M. Bigelow.

Guatemala: Coban, Alta Vera Paz, altitude, 4,300 to 4,400 feet, H. von Turckheim, No. 431, April, 1886, and April, 1879.

Brazil: "Brasilia meridionali," Sellow.

Juncus marginatus setosus var. nov.

Stems apparently in loose tufts, 30 to 75 cm. high; leaf blades 1 to 5 mm. broad; inflorescence and heads as described in *Juncus marginatus aristulatus;* inner perianth parts narrowly ovate to lanceolate, 0.3 to 0.4 mm. in length, reticulated in 12 to 16 longitudinal rows, the areolæ nearly isodiametrical, transversely plurilineolate.

Type specimen in the United States National Herbarium, collected June 4, 1882, in the Santa Catalina mountains, Arizona, by C. G. Pringle.

Specimens examined:

Kansas: Stafford and Kingman counties, M. A. Carlton, 1891.

Nebraska: Minden, Kearney county, June, 1891, intergrading with the type form.

Arizona: Santa Catalina mountains, C. G. Pringle, June 4, 1882, and April 14 and May 16, 1881; Lowell, W. F. Parish, May 24, 1884; Apache Pass, J. G. Lemmon, No. 313, 1881.

New Mexico: Charles Wright, No. 1923 in part, 1851.

Indian Territory: Colbert, C. S. Sheldon, No. 37, June 19, 1891; Russell Creek, W. S. Newlon, 1893.

Texas: Drummond, F. Lindheimer, No. 193, 1843; Corpus Christi, H. W. Ravenel, April 30, 1869; Houston, Elihu Hall, Pl. Tex. No. 657, April 20, 1872.

Arkansas: Little Rock, F. L. Harvey, June, 1880.

Louisiana: Port Eads, on ballast ground, A. B. Langlois, May 6, 1885.

Mexico: Near Morales, San Luis Potosi, J. G. Schaffner, No. 500, 1876; Rio Blanco, Jalisco, Edward Palmer, No. 13, June 8, 1886.

The considerations which have led to the disposition of the species formulated above may be given in sufficient detail to aid the future student who goes over the same ground.

The type specimen of *Juncus marginatus*, which is probably at Berlin, it has not been possible to consult, but Rostkovius's excellent figure, as well as his description of the plant, "*culmus erectus pedalis vel sesquipedalis*," "*corymbus terminalis simplex*," and "*capitula octo- vel decemflora*," besides the type locality, Pennsylvania, leave no doubt as to the identity of the type form. The type specimen of *Juncus cylindricus*, a fragment of which I have been able to examine in the Engelmann herbarium, bears heads with abnormally elongated axes and many flowers. It belongs clearly to some form of *Juncus marginatus*, probably to the type form. Dr. Engelmann, following a practice in common European use, gave to what he considered the type form a varietal name, *vulgaris*, which, by reference to No. 33 of his Herbarium Normale, is seen clearly to be identical with Rostkovius's plant. An examination of the type specimen of *Juncus marginatus paucicapitatus* in the Engelmann herbarium shows that it belongs to the type form of *Juncus marginatus*, and indeed closely resembles Rostkovius's original figure of the species.

The plant for which the name *Juncus marginatus aristulatus* is here adopted has been known currently as *Juncus marginatus biflorus*. Michaux's *Juncus aristulatus* has been referred by various authors to *Juncus marginatus* without particular comparison with any of its forms, but an examination of his description leaves no doubt regarding the plant he was describing, for in the expression "*glomerulis trifloris*" he names the most conspicuous external feature of this variety. Persoon's specific name *aristatus* is an error for *aristulatus*, for Persoon cited Michaux as the author of the name, with reference to the page of publication, and quoted his description with but slight changes. Regarding *Juncus biflorus*, it should be said that Elliott included in his book descriptions of two plants of the *marginatus* group, one, which he referred to *Juncus aristulatus* Mx. (citing it by error, apparently from Pursh, *Juncus aristatus*, and modifying Michaux's description to some extent), and another, which he described as a new species, *Juncus biflorus*, with the diagnosis "*Juncus culmo tripedali, tereti; foliis linearibus, planis; panicula decomposita, elongata; glomerulis bifloris.*" There can be no doubt that this plant is referable to true *Juncus aristulatus*, and that Elliott incorrectly transferred Michaux's name to some other form, perhaps the type form, of *Juncus marginatus*. Torrey's *Juncus marginatus odoratus*, the original specimen of which I have examined in the Columbia College herbarium, is *Juncus marginatus aristulatus*, with 3- to 5-flowered heads, and has now lost the pleasant odor, probably accidental, attributed to it by Dr. Torrey. Nuttall's *Juncus heteranthos* can be nothing else than *Juncus marginatus biflorus*, for although his type specimen appears to have been lost he states explicitly in his description that the flowers are mostly in threes, and that the inner perianth parts are obtuse. In describing the plant, therefore, he appears to have been distinguishing it from the common typical eastern form of *Juncus marginatus* and not to have had in mind Elliott's *Juncus biflorus*. The form ascribed to the inner perianth parts precludes its reference to *Juncus marginatus setosus*. The type specimen of Liebmann's *Juncus canaliculatus* has been examined by Dr. Franz Buchenau, who refers it unhesitatingly to *Juncus marginatus*.* Since he does not say that its inner perianth parts are acute, I judge that it is not *Juncus marginatus setosus*, which, indeed, is very unlikely to occur in the humid climate of Vera Cruz. Neither is Liebmann's plant referable to the type form of *Juncus marginatus*, for that plant does not range so far south. The *Juncus odoratus* of Steudel is based on *Juncus marginatus odoratus* Torr., to which reference has already been made, and Engelmann's *Juncus marginatus biflorus* is based upon *Juncus biflorus* Ell.

The variety described above as new could not, from its range, have been referable to any of the plants whose names have been cited above as synonyms of *Juncus marginatus* or its variety, with the exception of *Juncus heteranthos* and *Juncus canaliculatus*, and the reasons for the reference of these two plants to *Juncus marginatus aristulatus* have been given in the last paragraph.

The localities of specimens examined in the preparation of this paper have been taken from the labels in the herbaria of Harvard University, Columbia College, the Missouri Botanical Garden, and the Academy of Natural Sciences of Philadelphia, the private herbaria of Mr. William M. Canby and Captain John Donnell Smith, and the National Herbarium.

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* Abh. Naturw. Ver. Bremen, iii. 343–344 (1873).

The disposition which is here made of the type form and varieties of *Juncus marginatus* may serve as a general illustration of a method of dealing with species and varieties which is in accord with our present knowledge of the evolution of species and of the geographic relationship of these plants with each other. The writer, having first secured a considerable amount of material, separated the specimens into the three groups which their examination naturally suggested. Next the names which have been published for any one of these forms were taken up and the original descriptions and the type specimens examined. In some cases the types were not accessible, and under those circumstances it was necessary to identify the plant either by description alone or by the aid of collateral evidence. In this manner it is believed that the earliest name applied to each of these forms has been ascertained, one of them, as it proved, having never before received a distinctive name. The next step was to bring together a still larger number of specimens, identifying each one according to the facts already known, ascertaining the locality in which it was collected, and marking its position upon a map. It was found .that the type form of *Juncus marginatus* merges by a full series of intergrades into *Juncus marginatus aristulatus*, and that in the states of Nebraska and Kansas it seems to intergrade also with *Juncus marginatus setosus.* The latter shows a close relationship with the variety *aristulatus*, but, so far as indicated by the specimens examined, does not fully intergrade with it. The differences between these two, however, are so slight that there is reason to expect the occurrence of intergrades. The type form of *Juncus marginatus* ranges from Maine southward through the Atlantic States to Florida, and occurs again at a point in the province of Ontario opposite Detroit. The variety *aristulatus* ranges from New York city southward along the coastal plains to Florida, westward through all the States bordering the Gulf of Mexico, and northward, in the Mississippi valley, in apparently isolated localities, to southern Michigan. South of the United States it follows the eastern coast at least as far as Coban, Guatemala, and one specimen is reported to have been found in southern Brazil. The variety *setosus* occurs in the southern Great Plains region, ranging over western Kansas, Indian Territory, interior Texas, Arizona, and New Mexico, and southward in Mexico to the states of San Luis Potosi and Jalisco. An isolated locality is also known on ballast ground in Louisiana and another in Arkansas. The ranges of the type form and the variety *aristulatus* appear to overlap in the Atlantic States over a considerable area, but in reality they are pretty well distinguished, for the latter characteristically inhabits sandy plains, particularly those along the coast, while the type form grows more abundantly in upland moist areas.

The most widely diffused and probably the mother form of *Juncus marginatus* is its variety *aristulatus*, which is characteristic of the coastal plains from New York to Texas, and extends far up the Mississippi valley, occurring among the coast mountains of Mexico southward to Guatemala. *Juncus marginatus* proper is an outlying and probably derivative form, extending farther north and farther inland, and presents a variation in the direction of smaller size, more reduced inflorescence, and larger heads. *Juncus marginatus setosus* is a second derivative, with acute, more papery perianth parts, and smaller seeds, characteristic of moist places in the subarid regions westward from the range of the mother form.

This test by geographic range has checked and emphasized the results obtained by a merely morphological examination of specimens, and brings our knowledge of these plants into a form more clearly expressive of their developmental relations. The same method may without doubt be applied to any group of plants with highly important results.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTIONS OF EIGHT NEW GROUND SQUIRRELS OF THE GENERA *SPERMOPHILUS* AND *TAMIAS* FROM CALIFORNIA, TEXAS, AND MEXICO.

BY C. HART MERRIAM, M. D.

Among the undescribed rodents now in the collection of the Division of Ornithology and Mammalogy of the U. S. Department of Agriculture are eight new ground squirrels of the genera *Spermophilus* and *Tamias*. Five of these are specifically distinct from any heretofore described; the remaining three are well-marked subspecies. They are here described in advance of the more formal publications in which their relations and distribution will be discussed at length.

Spermophilus nelsoni sp. nov.

NELSON'S SPERMOPHILE.

Type from TIPTON, SAN JOAQUIN VALLEY, CALIFORNIA. No. 54651 ♂ ad. United States National Museum, Department of Agriculture collection. Collected June 24, 1893, by C. P. Streator (original number, 2968).

Measurements (taken in flesh).—Type specimen, ♂: total length, 228; tail vertebræ, 71; hind foot, 41. Mean of 29 specimens from type locality: total length, 228.6; tail vertebræ, 68.4; hind foot, 40.4.

General Characters.—Belongs to the subgenus *Ammospermophilus;* similar to *S. leucurus* in form and pattern of markings, but somewhat larger and widely different in color, the upper parts being yellowish-brown.

Color.—Upper parts dull yellowish-brown or buffy clay-color, which color covers the outer surfaces of the legs and the proximal third of the upper side of the tail; a white stripe on each side reaching from behind shoulder to rump; under parts, feet, and eyelids soiled whitish, the feet more or less strongly suffused with buffy. Tail above: proximal third buffy clay-color like back; distal two-thirds mixed black and whitish with a whitish border; tail below: soiled or buffy whitish, bordered on distal two-thirds with a broad subterminal black band, and edged with whitish. There is also a very narrow black zone at the base of the tail hairs. The upper parts are rather coarsely lined with black hairs which are absent from the legs, giving the latter a slightly different tint, and in some specimens the ground color of the legs and sides just above the forelegs is different, being suffused with dull buffy ochraceous. The fall and winter pelage is darker and softer than the summer pelage.

Cranial Characters.—Skull similar to that of *S. leucurus*, but larger and broader; audital bullæ conspicuously larger, more inflated and distinctly corrugated. The corrugations are due to the presence of two transverse constrictions, marking the position of vascular canals; they are faint or absent in *leucurus*, *harrisi*, and the other previously described forms. The rostrum and nasal bones are somewhat longer, and the upper incisors and first upper premolar are larger than in *leucurus*.

Specimens Examined (all from San Joaquin Valley, California).—Total number, 52, from the following localities: Tipton (type locality), 32; Huron, 7; Adobe Station, 1; Alila, 2; Lerdo, 2; Poso, 3; Temploa Mountains, 2; Lake Buena Vista, 3.

General Remarks.—The difference between *Ammospermophilus nelsoni* and the previously known members of the group is much more decided than between any of the others. The animal is larger, paler, and very different in color, the upper parts being everywhere from nose to tail a uniform dull yellowish or buffy clay-color, rather coarsely lined with black hairs. The cranial peculiarities have been already described. The fall molt evidently takes place early and progresses from behind forward, as shown by the 13 specimens collected by Mr. Nelson in October. All of these have completed or nearly completed the change, the only old hairs remaining being on the head and belly. In some of the specimens from Poso the pale, buffy clay-color of the head, still in worn summer pelage, is in striking contrast with the much darker tints of the neck and back which are completely covered with the new coat. The two are separated by a sharp line of demarkation that crosses the occiput between the ears.

Heretofore no species of the *Ammospermophilus* group has been recorded from the San Joaquin Valley, or in fact from any point west of the great divide. It is remarkable that a diurnal mammal as conspicuous as the present species, and one inhabiting a region traversed by a railroad over which numerous mammal collectors have passed again and again, should have remained undescribed to the present day.

Spermophilus perotensis sp. nov.

PEROTE SPERMOPHILE.

Type from PEROTE, VERA CRUZ, MEXICO. No. 54274 ♀ ad. United States National Museum (Department of Agriculture collection). Collected by E. W. Nelson June 8, 1893 (original number, 4976).

Measurements (taken in flesh).—*Type specimen*: Total length, 253; tail vertebræ, 68; hind foot, 39. Average of 14 specimens from type locality: total length, 249; tail vertebræ, 69; hind foot, 38.5.

General Characters.—This spermophile does not require comparison with any known species. In size and external appearance it resembles *S. elegans* of Wyoming, but its cranial characters show it to belong to another subgenus (*Xerospermophilus*). Ears a mere rim; tail rather short.

Color.—Upper parts grizzled yellowish brown, vermiculated posteriorly by irregularly interrupted lines of black (which in immature specimens, and probably also in new pelage in adults, form the posterior borders of indistinct buffy spots); eyelids white; under parts and feet buffy. Tail above, grizzled yellowish brown and black, the black predominating on the distal half; below, ochraceous buff, with a distinct subapical band of black encircling the distal half or two-thirds.

Cranial Characters.—In cranial characters *Spermophilus perotensis* clearly belongs to the subgenus *Xerospermophilus*, and to that part of the subgenus from which the ancestors of *S. mexicanus* branched off. The adult skull is larger and heavier than that of any other known member of the *spilosoma* group, and resembles *S. spilosoma major* more closely than any other species. The parietals are much more highly arched above the supraoccipital, the highest point being between the postorbital processes, behind which they are even more abruptly decurved than in *S. mexicana;* the supraorbital foramina are completely inclosed in the superciliary shelf. Molars heavy, their crowns very broad antero-posteriorly; first upper premolar relatively large. In many respects the skull of *S. perotensis* resembles that of *S. mexicanus.*

Geographic Distribution and Faunal Position.—The range of this species, according to Mr. Nelson, is "the extreme eastern border of the Mexican table-land at Perote, Vera Cruz, at an altitude of 7,800 or 7,900 feet." Its faunal position is along the upper border of the Upper Sonoran zone.

General Remarks.—Sixteen specimens of this new Spermophile are before me, all collected at Perote by Mr. Nelson. They vary but little, except in the degree of visibility of the obsolescent spots and the tint of the upper parts—differences resulting from the wearing off of the tips of the hairs.

Spermophilus spilosoma annectens sp. nov.

PADRE ISLAND SPERMOPHILE.

Type from Padre Island, Texas. No. $\frac{30410}{42396}$ ♂ yg.-ad. United States National Museum, Department of Agriculture collection. Collected August 24, 1891, by William Lloyd (original number, 694).

Measurements (taken in flesh).—Total length, 220; tail vertebræ, 60; hind foot, 36. In 8 adults from the type locality the tail vertebræ vary from 55 to 75 mm. and the hind foot from 35 to 38 mm.

General Characters.—*S. annectens* is about the size of *S. spilosoma major*, which it resembles in coloration and markings, though the pelage has a grayish cast suggesting *S. obsoletus.* Ear a mere rim, about 3 mm. high at highest point.

Color.—Upper parts dull grayish brown; back beset with ill-defined buffy spots, margined posteriorly with dusky in unworn pelage; under parts soiled white. Eyelids white. Tail concolor with back or a little more fulvous, its distal half or two-thirds bordered with a subapical black band beyond which the tips of the hairs are buffy-ochraceous. Immature specimens and young of the year are more brownish than the adults and show the spots much more distinctly, as usual in the *spilosoma* group.

Cranial and Dental Characters.—Compared with *S. spilosoma major*, the skull of *S. annectens* is longer, but is actually as well as relatively narrower across the zygomatic arches, particularly anteriorly, where the anterior roots are pinched in as in *Ictidomys;* frontals broader interorbitally; fronto-nasal region more convex; supraorbital foramina usually completely inclosed; postorbital processes more strongly decurved; audital bullæ smaller; postzygomatic notch almost obsolete; rostrum broader across the base, with the lateral angle less marked. Under jaw larger and heavier, with posterior edge of inflected angular process broader, shorter, and less transverse. The cranium as a whole is narrower and higher than in any known member of the subgenus *Xerospermophilus.*

The dentition is unusually heavy for the subgenus, and the crown of the last upper molar is about as long antero-posteriorly as transversely. The first upper premolar is about one-third the size of the second. In all of these respects, except the character of the angular process of the mandible, the cranial peculiarities of *S. annectens* depart from the *S. spilosoma* type and resemble the *S. mexicana* type.

General Remarks.—Fourteen specimens of this animal are in the Department collection, 13 from Padre Island, Texas, and 1 from the mainland at the mouth of the Rio Grande. Padre Island is a long spit of sand in the Gulf of Mexico just north of the mouth of the Rio Grande.

Spermophilus beecheyi fisheri subsp. nov.

FISHER'S GROUND SQUIRREL.

Type from Kern Valley, California (25 miles above Kernville). No. $\frac{29318}{41385}$ ♂ ad. United States National Museum, Department of Agriculture collection. Collected July 6, 1891, by Dr. A. K. Fisher (original number, 741).

Measurements of Type Specimen (taken in flesh).—Total length, 415; tail vertebræ, 175; hind foot, 58.

General Characters.—Similar to *S. beecheyi*, but everywhere much paler; sides of neck and shoulder-stripes clear silvery white, in striking contrast with the color of the body; sides of body thickly beset with indistinct whitish spots, narrowly bordered with dusky posteriorly. (In true *beecheyi* the spots are much less numerous, less distinct, and tend to run together so as to form irregular transverse bands.) Ear stripe not sharply defined and not so pure black as in *beecheyi;* eyelids and lower part of face whitish; under parts and feet buffy.

General Remarks.—This large ground squirrel is by far the most striking and handsome of the subgenus *Otospermophilus*, and I take pleasure in naming it in honor of one of the naturalists of the Death Valley Expedition, Dr. A. K. Fisher, who collected the type specimen. Numerous specimens were obtained by the expedition in Kern Valley, Walker Pass, Owens Valley, and in the Coso, Argus, and Panamint Mountains, California.

Spermophilus chrysodeirus brevicaudus subsp. nov.

SAN BERNARDINO SPERMOPHILE.

Type from San Bernardino Peak, California. No. 56661 ♀ ad. United States National Museum, Department of Agriculture collection. Collected October 9, 1893, by J. E. McLellan (original number, 274).

Measurements of Type Specimen (taken in flesh).—Total length, —; tail vertebræ, —; hind foot, —.

General Characters.—Similar to *S. chrysodeirus*, but with much shorter tail, somewhat shorter hind foot, and duller mantle over head and shoulders. The tail averages about 75 mm., while that of *chrysodeirus* averages 90 mm. or more.

Color (of type specimen).—Back and rump grizzled gray tinged with brownish; sides paler; a dull fulvous mantle over head and neck, hardly reaching shoulders; color of head shading toward brick-red; sides of neck behind ears buffy-ochraceous; a broad whitish stripe, bordered on each side by a broad black stripe, extends from the shoulder to the rump on each side, and the white reaches beyond the black in both directions; hind foot dull whitish: tail above, proximal half grizzled; distal half black, edged with fulvous; tail below, chestnut, bordered with black and edged with fulvous.

Number of specimens examined, 7; all from San Bernardino Mountains, California.

Tamias panamintinus sp. nov.

PANAMINT CHIPMUNK.

Type from Panamint Mountains, California (between Death Valley and Panamint Valley). Exact locality, Johnson Cañon. No. $\genfrac{}{}{0pt}{}{27603}{39702}$ ♂ ad. United States National Museum, Department of Agriculture collection. Collected by E. W. Nelson April 3, 1891 (original number, 723).

Measurements of Type Specimen (taken in flesh).—Total length, 208; tail vertebræ, 96; hind foot, 31. Ear from notch, 16 (measured in dry skin). Average measurements of 50 adult specimens from type locality: total length, 208; tail vertebræ, 90.4; hind foot, 31.

General Characters.—About the size of *T. quadrivittatus*, but resembles *T. speciosus* much more closely in coloration, being a paler form with obsolescent facial stripes and less distinct dorsal stripes, which are shorter posteriorly, leaving the rump clear gray. Ears smaller than in *speciosus;* ear stripes nearly obsolete. Tail rich orange-rufous both above and below and only narrowly margined with black. Hind foot shorter than in any other member of the *speciosus* group.

Color.—Winter pelage: Top of head and rump ash gray; back of neck and inner pair of dorsal light stripes pale vinaceous drab, fading into gray posteriorly; dorsal stripes short, not continuing over rump; outer pair of light stripes dull whitish; all five dark dorsal stripes dull fulvous; sides gray, washed with buffy ochraceous. Face stripes indistinct; those below the eye obsolete. *Tail:* upper surface rich orange rufous (from the broad sub-basal zone of this color), which is only heightened by the narrow subapical zone of black and the yellowish tips of the hairs; under surface deep orange rufous, with a narrow submarginal band of black, bordered with yellowish.

Summer Pelage: Similar to winter pelage, except that the sides and dark dorsal stripes are suffused with ferruginous, and the median part of the central stripe is blackish posteriorly.

Cranial Characters.—Skulls of *T. panamintinus* resemble those of *T. quadrivittatus* from the type locality in Colorado so closely that the two are hardly distinguishable, though the skull of the Panamint animal is slightly smaller and more depressed in the fronto-nasal region, and has larger audital bullæ. Contrasted with *T. speciosus*, the brain case is flatter and the audital bullæ conspicuously larger.

General Remarks.—In winter pelage *panamintinus* differs from *speciosus*, the only form with which it requires comparison, in having all of the stripes less distinct, particularly those of the face and ears; the dorsal stripes shorter, not running back over the rump, which is clear gray; the outer pair of white stripes narrower, shorter, and less pure white; the dark dorsal stripes pale fulvous instead of dark umber; the shoulders and back of the neck suffused with buffy-ochraceous instead of being gray, and the rufous of the distal half of the tail not obscured by black.

In summer pelage it resembles *speciosus* much more closely, but may be distinguished by less vivid tints, paler facial stripes, narrower outer dorsal white stripe, obsolescent ear stripes, pale gray rump, and by the small amount of black on the tail. In all pelages the black on the tail is very much restricted, permitting the rufous to show through on the upper surface for its entire length, thus imparting to it a peculiar ruddy glow not seen in any other species.

Geographic Distribution.—*Tamias panamintinus* is an inhabitant of the desert ranges of the west side of the Great Basin in California and Nevada, where 110 specimens were obtained by the Death Valley Expedition.

Tamias callipeplus sp. nov.

MOUNT PIÑOS CHIPMUNK.

Type from summit of MOUNT PIÑOS, VENTURA COUNTY, CALIFORNIA. No. $\frac{31299}{43164}$ ♂ yg.-ad. United States National Museum, Department of Agriculture collection. Collected by E. W. Nelson October 20, 1891 (original number, 1344).

Measurements of Type Specimen (taken in flesh).—Total length, 212; tail vertebræ, 92; hind foot, 33.5. Average measurements of four specimens from type locality: total length, 210; tail vertebræ, 91.7; hind foot, 34.

General Characters.—Agrees with *speciosus*, its nearest relative, in size, proportions, and pattern of markings, including the great breadth of the outer white dorsal stripe. It differs from *speciosus* in having the thighs and rump yellowish instead of gray, the back of the neck and inner pair of light dorsal stripes vinaceous-drab instead of gray; the post-auricular patches larger, purer white, and more sharply defined, and the black on the tail much less extensive. Ears large.

Color.—*Winter pelage:* No gray anywhere; top of head, back of neck, and inner pair of light dorsal stripes vinaceous drab, tinged with ochraceous on the shoulders, becoming fulvous on the flanks, and yellowish on the thighs and rump; outer white stripes very broad (as in *speciosus*) and slightly obscured posteriorly by dark-tipped hairs; median dorsal stripe dark umber-brown, bordered and obscured by rusty; inner pair of dark stripes ferruginous; outer pair fulvous, not defined below, passing into fulvous of flanks; post-auricular spots large, sharply defined, and pure white; ear stripes sharp, the posterior pure white, the anterior black, edged in front basally with rusty; facial stripes intensely colored and sharply defined, the middle or orbital stripe black, becoming rusty at the base of the ear; feet faintly washed with fulvous; tail orange rufous, broadly tipped and narrowly bordered with black, and edged with yellowish; the rufous obscured on upper surface by black subapical and yellowish apical zones on the hairs; belly and throat pure white, the dark basal color showing through in places.

Cranial and Dental Characters.—No cranial characters of importance have been discovered, though the brain case is slightly more arched in the posterior frontal region than in *speciosus*. The molariform teeth are somewhat heavier, and the last upper molar has the heel more developed.

General Remarks.—Tamias callipeplus differs from both *speciosus* and *panamintinus* in having the hinder parts of the body yellowish instead of gray, and in the purer white and larger size of the post-auricular spots. It agrees with *panamintinus* and differs from *speciosus* in the vinaceous tinge of the back of the neck and inner pair of pale dorsal stripes, and in the color of the tail. It differs from *panamintinus* and agrees with *speciosus* in the brightness and sharpness of the facial stripes and ear stripes, the great breadth of the outer pair of dorsal white stripes, in the posterior extension of the dorsal stripes over the rump, and in the large size of the hind foot.

Tamias callipeplus is treated as a full species instead of a subspecies on account of its isolated geographic position, intergrades being impossible because the mountains on both sides of Mount Piños do not attain sufficient altitude to provide the cool temperature required by the species.

Tamias alpinus sp. nov.

ALPINE CHIPMUNK.

Type from BIG COTTONWOOD MEADOWS, HIGH SIERRA, CALIFORNIA, just south of Mount Whitney (altitude, 3,050 meters or 10,000 feet). No. $\frac{30507}{42491}$ ♀ yg.-ad. United States National Museum, Department of Agriculture collection. Collected by Basil Hicks Dutcher August 12, 1891 (original number, 191).

Measurements of Type Specimen (taken in flesh).—Total length, 189; tail vertebræ, 82; hind foot, 29. Ear from notch, 13 (in dry skin). Average measurements of 15 specimens from type locality: total length, 185; tail vertebræ, 79; hind foot, 29.3.

General Characters.—Size, small; resembles *T. minimus pictus* in size, proportions, and general appearance, but is much paler in breeding pelage and much more ferruginous in midsummer pelage; may be distinguished from *pictus* in all pelages by the tail, which is much broader and more bushy, hoary above, and broadly tipped with black both above and below.

Color.—Fall pelage: General color of upper parts, hoary gray, suffused on the flanks with buffy-ochraceous; median dorsal stripe dusky, obscured by pale rusty; lateral dorsal dark stripe pale ferruginous; inner pair of white stripes hoary gray; outer pair white and very broad (as in *speciosus*); post-auricular patches whitish, not sharply defined; facial stripes pale; ear stripes indistinct; legs and feet gray. Tail: upper surface hoary (rarely yellowish), becoming black toward the tip (the individual hairs buffy gray sub-basally, then black, and broadly tipped with pale buffy gray or yellowish); under surface, pale buffy fulvous, bordered and broadly tipped with black, broadly edged laterally with pale buffy.

Summer Pelage: Dorsal dark stripes bright ferruginous; facial stripes strengthened by dull rusty; flanks bright fulvous, the fulvous reaching forward over shoulders to sides of neck.

Cranial Characters.—Skull similar in size and general appearance to that of *T. minimus pictus*, but with longer nasals and nasal branches of premaxillaries. The length of the nasals equals or exceeds the combined length of the basioccipital and basisphenoid. In *minimus* the nasals fall considerably short of this measurement.*

General Remarks.—The Alpine chipmunk is one of the two smallest chipmunks known, the other being the Sage Plains species (*T. minimus*), which it resembles in general appearance, except in the full summer pelage. In all pelages it may be distinguished from *minimus* by the tail, which is hoary above (rarely yellowish); is broader and more bushy, and has the black terminal part much longer. The outer pair of white dorsal stripes also are much broader, as in *speciosus.* In spring and early summer, before the post-breeding molt, the animal is very much paler than the palest specimens of *minimus pictus.* In midsumer pelage, on the other hand, the sides and dark stripes are deeper ferruginous than ever seen in the brightest summer specimens of *minimus pictus* or even *minimus consobrinus*, and in high-colored individuals even the inner pair of light stripes are sometimes obscured by rusty.

Geographic Distribution.—This beautiful little chipmunk is restricted, so far as known, to the alpine summits of the High Sierra, where it lives among rocks at timber-line, ranging a little above and a little below the upper limit of tree growth. Thus the haunts of the alpine chipmunk are the same as those of the pika (*Lagomys*), the alpine marmot (*Arctomys flaviventer*), and the mountain sheep (*Ovis canadensis*). No mammal ranges higher. Sixty specimens were obtained by the Death Valley Expedition.

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* This has been verified in 100 skulls, 50 of *alpinus* and 50 of *minimus* and subspecies.

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PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON.

DESCRIPTION OF A NEW SPECIES OF *ARVICOLA*, OF THE MYNOMES GROUP, FROM ALASKA.

BY E. W. NELSON.

Arvicola operarius sp. nov.

THE TUNDRA MOUSE.

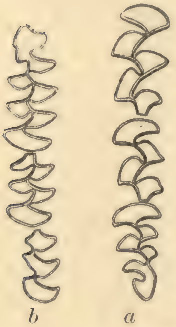
Arvicola riparius borealis Nelson and True, Report upon Natural History Collections in Alaska, 1887, pp. 275, 276, Series A (not Richardson).

Type No. $\frac{14379}{22225}$. United States National Museum. From St. Michaels, Norton Sound, Alaska. November, 1879. Collected by E. W. Nelson.

Measurements.—Average measurements, in millimeters, of five dried skins, fall and winter specimens, from St. Michaels are as follows: Total length, 104.5; length of tail vertebræ, 25.2; hind foot, 17.9; ear from front base, 9.8.

Color.—The dorsal surface, including the top and sides of the head, is pale, dull fulvous or fawn color, thinly washed with darker from the overlying black tips of the long hairs. On the sides the fulvous of the back shades gradually into the paler lower surface and sometimes forms a faint wash over most of the under parts. The top of the tail is dark brown, in contrast with the color of the back, and its sides and lower surface are white. The under surface is plain, dull, grayish white, including upper lips, chin, and throat, and extending laterally to the insertion of the legs. In some cases the white area is separated from the white under surface of the tail by a narrow band of fulvous which incloses the base of this member below. The feet and legs are dull whitish. The fur is long and very soft, except on the tail. The tail hairs are rather coarse and stiff and the terminal pencil is peculiarly bristly with a length of 6 mm.

The ears are rounded and clothed on the inner side of conch by yellow hairs. They are wholly concealed by the fur.



Molar teeth of *Arvicola operarius* x 5. *a*, upper; *b*, lower.

The under fur, with basal two-thirds of the long hairs, is of a uniform dark slaty color; succeeding the dark base the majority of the long hairs of the back have a plain fulvous tip. The tips of the longest hairs, however, are black, succeeding a yellowish zone, thus producing a slight wash of darker over the back.

A slight variation in color is apparent among the specimens, due to the varying intensity of the fulvous. The soles of feet are naked. The thumb nail is short, stout, and spatulate and does not extend beyond end of the thumb.

Dentition.—The accompanying figure shows the pattern of the crowns of the molar teeth.

Skull measurements of five specimens of *Arvicola operarius* from St. Michaels, Alaska:

U. S. National Museum numbers..	22225	22212	22224	22214	22223
Basilar length of Hensel.........	21.	21.	21.	21.	20.75
Greatest zygomatic width........	12.5	12.5	12.5	12.75	12.5
Interorbital constriction..........	3.5	3.5	3.5	3.25	3.5

The present species may be readily distinguished from any known American *Arvicola* by its smaller size and pale fulvous color. It is very abundant along the coast tundras of Bering Sea from Cape Vancouver north at least to Bering Straits, including Nelson, St. Michaels, and Stewart Islands. It makes numerous runways through the moss and under the grass in all the tundra districts where it lives, and as winter approaches gathers stores of small bulbous roots, sometimes placing a peck or more in a single cavity just below the surface on a mossy knoll or slope.

For a short period before the first snowfall in autumn the Eskimo women and children search for these stores with pointed sticks, which they thrust into the sides of mossy banks in suitable places, the spot being found by the ease with which the stick penetrates the few inches of mossy cover. In this way considerable quantities of this food are gathered, and during the following winter it is boiled and eaten as a delicacy. The boiled roots have a flavor like a boiled unripe sweet potato and are very palatable during the long winter fare of meat and fish. During seasons when the snow remains on the ground from fall until spring, comparatively few of these mice come about the houses until the snow begins to melt in spring, when they always become numerous there.

A winter thaw occurs at intervals of several years, melting away nearly all of the snow. At such times the water percolates into all of their runways and storehouses, and the quickly succeeding cold freezes them solid for the remainder of the season. In this way the majority of these mice are at once bereft of shelter and food, and are found wandering about on the surface of the tundras, where many are eaten by foxes and other animals, while others freeze to death, and scores swarm about the native villages and the fur-trader stations.

Ordinarily in spring, as the snow melts away, many winter burrows are revealed just at the lower surface of the snow. Their burrowing can never extend very deep in many places where the permanently frozen soil lies at a depth of from one to two feet. On a dry peat knoll fronting the sea near St. Michaels I once followed their holes to a depth of about two feet.

The Eskimo boys trap them in toy traps modeled after those used by the men for larger game, and the children use their skins for blankets and clothing for dolls.

These mice are omnivorous, and when two or more are confined together in a box the stronger usually kill and partly devour the weaker.

Through the kindness of Dr. C. Hart Merriam I am able to present herewith a plate showing the character of the dentition of this species. I wish also to acknowledge herein my indebtedness to the courtesy of Mr. F. W. True, Curator of Mammals in the United States National Museum, who kindly placed the specimens of the Alaskan *Arvicolæ* at my disposal.

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PROCEEDINGS

OF THE

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PRELIMINARY DESCRIPTIONS OF FOUR NEW MAMMALS FROM SOUTHERN MEXICO, COLLECTED BY E. W. NELSON.

BY C. HART MERRIAM, M. D.

Lepus orizabæ sp. nov.

MT. ORIZABA COTTONTAIL.

Type from Mt. Orizaba, State of Puebla, Mexico (altitude about 9,500 feet). No. 53318 ♀ ad. United States National Museum, Department of Agriculture collection. Collected April 24, 1893, by E. W. Nelson (original number, 4730).

Measurements of Type Specimen (taken in flesh).—Total length, 395; tail vertebræ, 51; hind foot, 90.

General Characters.—Similar to *L. arizonæ* in general appearance and length of ear, but very much darker and differing considerably in color; pectoral band broad and full, forming a distinct ruff.

Color.—Head, back-saddle, and thigh streaks grizzled buffy clay-color and black, the admixture of black plentiful and uniform; flanks and rump mixed gray and black, the gray particularly clear on rump; upper side of tail grizzled drab-gray, with tips of hairs buffy; nape patch and fore and hind feet, dull fulvous, palest on inner sides of hind feet; pectoral collar drab, with tips of long hairs buffy; chin, throat, middle of belly and under side of tail, pure white with under fur plumbeous except under tail, where the fur is white throughout; ears dull grayish brown, bordered apically with a brown band, which is not very well defined; anterior edge fringed with whitish.

Cranial Characters.—Skull similar to that of *L. arizonæ*, but with audital bullæ much smaller.

Sciurus nelsoni sp. nov.

NELSON'S SQUIRREL.

Type from Huitzilac, Morelos, Mexico. No. 51157 ♀ ad. United States National Museum, Department of Agriculture collection. Collected January 1, 1893, by E. W. Nelson (original number, 4144).

Measurements of Type Specimen (taken in flesh).—Total length, 500; tail vertebræ, 246; hind foot, 68. Average measurements of 4 specimens from type locality: Total length, 527; tail vertebræ, 262; hind foot, 70.

General Characters.—Premolars $\frac{2}{1}$; size large, about equaling *S. cervicalis;* color of upper parts uniform. No trace of nuchal patch or rump patch.

Color.—Type Specimen: Upper parts from nose to tail grizzled yellowish brown; under parts grizzled fulvous, purest on throat and breast, much mixed with black posteriorly; end of nose, ears, and feet black, the feet (both fore and hind) more or less grizzled (probably a seasonal character, as the feet are wholly black in most of the specimens); tail black; upper side with tips of hairs whitish; under side bordered with whitish. Below the broad subterminal black zone there is a concealed zone of dull fulvous.

Other Specimens.—Some specimens are much darker than others, and the difference seems to be seasonal. In some the head, feet, and legs are intense black. The feet are almost wholly black in nearly all the 14 specimens, and the under parts are usually blacker than in the type. The tail is usually black, washed above and on the sides with whitish, but in some specimens the under side is grizzled from admixture of black and dull buffy-gray. Two or three of the specimens show a whitish spot (usually rather indistinct) at the posterior base of the ear.

Specimens examined, 14: 4 from Huitzilac, Morelos; 9 from Ajusco, Mexico, and 1 from Salazar, Mexico.

Thomomys orizabæ sp. nov.

MT. ORIZABA THOMOMYS.

Type from Mt. Orizaba, State of Puebla, Mexico (altitude, about 9,500 feet). No. 53616 ♀ ad. United States National Museum, Department of Agriculture collection. Collected April 25, 1893, by E. W. Nelson (original number, 4744).

Measurements (taken in flesh).—Type specimen: Total length, 217; tail vertebræ, 68; hind foot, 30. Average measurements of 13 specimens from type locality: total length, 213; tail vertebræ, 66; hind foot, 29.

General Characters.—Size medium; sooty-plumbeous phase dominant; fulvous phase resembling *T. fulvus*, but duller. Tail longer than in *T. fulvus;* well haired; fore and hind feet well haired.

Color.—Plumbeous phase (the type and 15 out of a total of 17 specimens from type locality are in this phase): Everywhere uniform slate-black (faintly paler below) except distal part of fore and hind feet, distal third of tail, and inside of cheek pouches, which are white (sometimes also a few white hairs about mouth and under chin). The color of the body always passes down over the wrists and ankles and usually reaches half way to the toes—sometimes further.

Fulvous phase: Upper parts dark umber-brown, becoming dusky on nose and dull fulvous on sides; under parts buffy-fulvous, the plumbeous basal fur showing through in places; under side of face blackish; feet and distal third of tail white. (Only 2 specimens, one of which is very young, out of a total of 17, are in this pelage.)

Cranial Characters.—The skull of *T. orizabæ* differs from that of *T. peregrinus* here described (the only species thus far recorded from southern Mexico) in the following particulars: Muzzle longer and much broader; frontals anteriorly much broader; ascending branches of premaxillæ much broader and blunter posteriorly. The breadth of muzzle across ascending branches of premaxillæ, and breadth of frontals anteriorly, is considerably greater than the interorbital breadth; in *peregrinus* the contrary is true.

Thomomys peregrinus sp. nov.

WANDERING THOMOMYS.

Type from Salazar, State of Mexico. No. 50130 ♀ yg.-ad. United States National Museum, Department of Agriculture Collection. Collected October 23, 1892, by E. W. Nelson (original number, 3668).

Measurements (taken in flesh.)—Type specimen: Total length, 207; tail vertebræ, 72; hind foot, 28.5. Average measurements of 10 specimens from type locality: Total length, 201; tail vertebræ, 57; hind foot, 28.

General Characters.—Similar to *T. fulvus*, but much darker and duller, lacking the bright golden-fulvous tints of that species, and differing also in cranial characters. The incisors curve far forward.

Color.—Upper parts dark umber-brown, becoming sooty-black on head and along middle of back, and dull fulvous on sides; end of nose, broad ring round mouth, and ear-patches blackish; under parts buffy, the plumbeous basal fur showing through; toes of fore feet, most of hind feet, and distal ⅓ or ½ of tail white. On the hind feet the dark color of upper parts reaches down over ankles; on fore feet it usually comes down to or near bases of toes.

Cranial Characters.—Compared with *T. orizabæ* the muzzle is very narrow, the breadth across ascending branches of premaxillæ being much less than the interorbital breadth. The frontals anteriorly are also considerably narrower than interorbitally, and the premaxillæ are slender and pointed posteriorly. In young and middle-aged skulls the interparietal is straight posteriorly, broadly rounded anteriorly, and nearly twice as broad as long; in old skulls it is roughly subquadrate.

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PROCEEDINGS

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THE YELLOW BEAR OF LOUISIANA, *URSUS LUTEOLUS* GRIFFITH.

BY C. HART MERRIAM, M. D.

Ursus luteolus Griffith, Order Carnivora, 1821, 236–237, with colored plate.
Ursus americanus Baird, Mammals of North America, 1857, 217 and 222 (in part—*not* of Pallas).
Ursus cinnamomeus Brown, Forest and Stream, December 16, 1893, 519 (in part—*not cinnamomum* of Audubon and Bachman).

In the year 1800 Shaw mentioned and in part described a yellow bear from the southern United States, but did not give it a specific name, referring it to the black bear as a variety, with a query. His account in full is as follows: "Yellow bear. Among Mr. Catton's figures of quadrupeds a representation is given of a yellow bear from the living animal then kept in the Tower. The following is the description accompanying the plate referred to: 'The yellow bear from Carolina (as the American bears in general are) is rather smaller than the European bears; it has also a more pleasant and agreeable countenance, is perfectly tame and sociable; the color a lively, bright orange, of a reddish cast; the hair thick, long, and silky. Its other properties are the same as of the species in general.'" (General Zoölogy, vol. I, part II, Mammalia, 1800, p. 454.)

In 1821 Edward Griffith, in his important and rather rare work on the Carnivora, named this bear *Ursus luteolus*, and gave a colored plate of it. His description is as follows: "Yellow bear. *Ursus luteolus.* The American yellow bear has been spoken of as a variety of the black bear of that continent. Independently of the individual mentioned in Shaw's Zoölogy, Major Smith has a drawing of one, taken in Louisiana,* and there is a fine specimen now in the Tower, which is aptly called, from its color, the cinnamon bear. This last is smaller; the forehead more convex; the nose more conical than in the black species; the ears also stand farther back; the physiognomy may be said to be more fox-like, and the hair is not so long or thick. It is gentle in disposition, which, indeed, is expressed in the countenance of the animal very decidedly. We cannot, therefore, but conclude that the hereditary distinctive differences of color, organization, and moral character are quite sufficient to constitute this a separate species.

"The yellow bear was formerly common in Virginia, and is still frequently met with in northwestern Louisiana, where it is called the white bear, and seems generally, though without doubt erroneously, to be considered an accidental variety, the offspring of the black bear. It subsists on honey, acorns, &c., as well as flesh." (Descriptions of Vertebrated Animals, Order Carnivora, London, 1821, 236–237, and col. pl.)

Six years later, in the mammal part of his well-known edition of Cuvier's *Animal Kingdom*, Griffith reluctantly treats the species as a variety of the American black bear, saying: "The Baron [Cuvier] also thinks that the yellow bear of Carolina is a variety of the same species. This is scientifically termed the *Ursus luteolus.* We shall not venture to assert, in contradiction to the authority of the Baron, that this bear forms a distinct species, but assuredly it is a very strongly marked variety. * * * They were formerly common in Virginia, and they are still abundant in northwestern Louisiana, where they are called white bears, and are said to feed chiefly on honey, on acorns of a large size, wild berries, &c." (Griffith's Cuvier, Mammalia, II, 1827, 228–229.) Whether or not two distinct bears were confounded in the original description is of little consequence, the fact remaining that Griffith's *Ursus luteolus* was based primarily upon the Louisiana animal—figured by Major Hamilton Smith; hence his name must hold for the species if it is found distinct from the common black bear of the eastern United States (*Ursus americanus*).

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* Lest any one should suppose that the old Territory of Louisiana, stretching westward to the Rocky mountains, was meant, it may be stated that the present boundaries of Louisiana were fixed in 1812, nine years before the publication of Griffith's original description and fifteen years before his second.

When engaged upon a revision of the North American bears some time ago I was struck by certain cranial and dental peculiarities possessed by five skulls* from Prairie Mer Rouge, Morehouse parish, Louisiana, which led me to regard the species as very distinct from the two species now commonly recognized as inhabiting the United States, namely, *Ursus americanus* Pallas and *U. horribilis* Ord. Owing to the absence of skins of this animal, and the rather scanty material illustrative of several other points concerned in a proper elaboration of the group, publication of the review in question was deferred. The recent appearance of an article by Mr. Arthur Erwin Brown,† superintendent of the Zoölogical Garden at Philadelphia, in which this remarkable bear is in part described, though wrongly referred, makes it desirable to issue a preliminary description of the species, based on the meager material now in hand. The following description is based wholly on the skulls from Mer Rouge, Louisiana, of which No. 1155 may be regarded as the type.

Cranial Characters.—Skull long and flat; fronto-parietal region depressed; profile of top of skull (including crest) nearly a straight line; sagittal crest long and high, about half the length of upper side of skull in old age. Contrasted with old skulls of male black bears from the Adirondacks, in northern New York, the three old male skulls from Mer Rouge, Louisiana, differ uniformly in the following particulars: They are longer and flatter; the occipito-sphenoid length ‡ is greater; the distance from foramen magnum to plane of front of last upper molar is greater; the ratio of zygomatic breadth to basilar length is less; the ratio of postpalatal length § to occipito-sphenoid length is considerably greater.

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* These skulls have been in the United States National Museum many years and some of their peculiarities were mentioned by Baird in his great work on the Mammals of North America in 1857.

† Forest and Stream, New York, Dec. 16, 1893, 518–519.

‡ Occipito-sphenoid length—distance from anterior lip of foramen magnum to suture between basisphenoid and presphenoid.

§ Post-palatal length—distance from anterior lip of foramen magnum to post-palatal notch.

The largest of the three old male skulls from Mer Rouge, Louisiana (No. 1155 United States National Museum), affords the following measurements: Basal length (basion to front of premaxilla), 292; basilar length of Hensel, 288; zygomatic breadth, 187; occipito-sphenoid length, 89; postpalatal length, 134; distance from inferior lip of foramen magnum to plane of front of last upper molar, 193; interorbital breadth, 68; distance betwean postorbital processes, 97; occipito-nasal length, 276; greatest length of skull, 326.

Dental Characters.—Molars larger than in any known species of the black bear group (subgenus *Euarctos* Gray); last upper molar in particular very large and notable for its great breadth as well as length, measuring 30 by 17 mm. in an old male from Prairie Mer Rouge (No. 1155), and doubtless larger in early life, as the tooth is much worn; the first upper molar in the same specimen measures 19.5 by 15.7 mm. The fourth lower premolar is trituberculate, having distinct cusps on the cingulum both anteriorly and posteriorly.* The latter is notched in the middle longitudinally, giving it a double crown. In addition to these cusps, one of the females with less worn teeth than the others has a small but distinct peg-like projection rising from the cingulum on the inner side near the middle, and closely pressed against the main cusp, from which it projects only slightly. But this tooth is subject to so much individual variation in bears from the same locality that it would be unsafe to place any reliance on the peculiarity here described unless it is found to hold good in a larger number of individuals than are now available for comparison. Traces of it exist, however, in the other female from Prairie Mer Rouge (No. 988), which is older and has the teeth more worn.

Color.—The name 'yellow bear' given to this species by Shaw and Griffith points to a marked peculiarity of coloration, and Mr. Arthur Erwin Brown, in his interesting article already referred to, describes one of his specimens as "flaxen color, with traces of a darker shade on the nape." The skull and teeth of this specimen are not described, but the inference is that they agree with the Ozark skull. Another bear, believed by Mr. Brown to be this species, is described as follows: "The color of the specimen now living [in the Philadelphia Zoölogical Garden] is in autumn a rich reddish brown, almost bay. As his coat becomes worn and faded he becomes pale yellowish brown. the color being generally uniform over the body."* This bear was presented to the garden by the late General James S. Brisbin, then stationed at Omaha, Nebraska, from which circumstance Mr. Brown infers that it came from the Rocky Mountain region—an inference that hardly seems safe, particularly if the animal really proves to be *U. luteolus.* On the other hand, it is by no means certain that *luteolus* is always yellow; and if I were to hazard a conjecture, in view of what little is known on the subject, it would be to the effect that the normal color is black.

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* Black bears from the Adirondacks and various other places often have a distinctly trituberculate crown to the tooth in question (pm$_{\overline{4}}$), but they lack the other peculiarities mentioned.

Geographic Distribution.—Very little is known of the geographic distribution of this bear further than the fact that it inhabits Louisiana. It may be found to range over much of the lowlands of the Gulf and South Atlantic states, and to intergrade with the black bear of the mountains of Tennessee and the Carolinas. A semi-fossil skull from the bed of an old stream near Fort Worth, Texas, examined by me, and the skull found by Professor Cope in a cave in the Ozark hills, in southern Missouri, recently described by Mr. Arthur E. Brown, may belong to an ancestor of this species rather than the species itself.

The name *cinnamomum* of Audubon and Bachman † cannot be applied to this species, because *luteolus* has thirty-three years' priority, and also because *cinnamomum* was based on an animal from the northern Rocky mountains, which has small molars, like the common black bear of the northeastern United States.

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*Forest and Stream, December 16, 1893, 518.

† *Ursus americanus* var. *cinnamomum* Audubon and Bachman, Quadrupeds of North America, vol. iii. 1854, 125–127.

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